7.1 RISK ASSESSMENT

7.1.1 INTRODUCTION

The objective of the RA study is to identify major risk contributing events, demarcate vulnerable zones and evaluate the nature of risk posed to nearby areas due to proposed drilling activity, in addition to ensure compliance to statutory rules and regulations. The scope of work for the study is described below:

- ✓ Identify potential risk scenarios that may arise from the proposed drilling and other associated activities
- ✓ Analyze the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data.
- ✓ Predict the consequences of such potential risk scenarios and if consequences are high, establish the same by through application of quantitative simulations.
- ✓ Recommend feasible preventive and risk mitigation measures as well as provide inputs for drawing up of Emergency Response Plan (ERP) for the project.
- ✓ The assessments to be based on various existing documents including Emergency Response Plan (ERP), Disaster Management Plan (DMP).

The scope involves risk assessment of Well Pad including Diesel Day Tank located at project site that would have a detrimental impact to the personnel and plant properties.

7.1.2 METHODOLOGY & APPROACH

Risk analysis consists of hazard identification studies to provide an effective means to identify different types of hazard during the operation of the facility. This is followed by an assessment of the impacts of these hazards.

Hazard is present in any system, plant or unit that handles or stores flammable materials. The mere existence of hazards, however, does not automatically imply the existence of risk. Screening & ranking methodologies based on Preliminary Hazard Analysis (PHA) techniques have to be adopted for risk to be evaluated.

The approach and methodology by ABC Techno Labs followed for the Risk Assessment study are described hereunder:

The study comprises of the following stages:

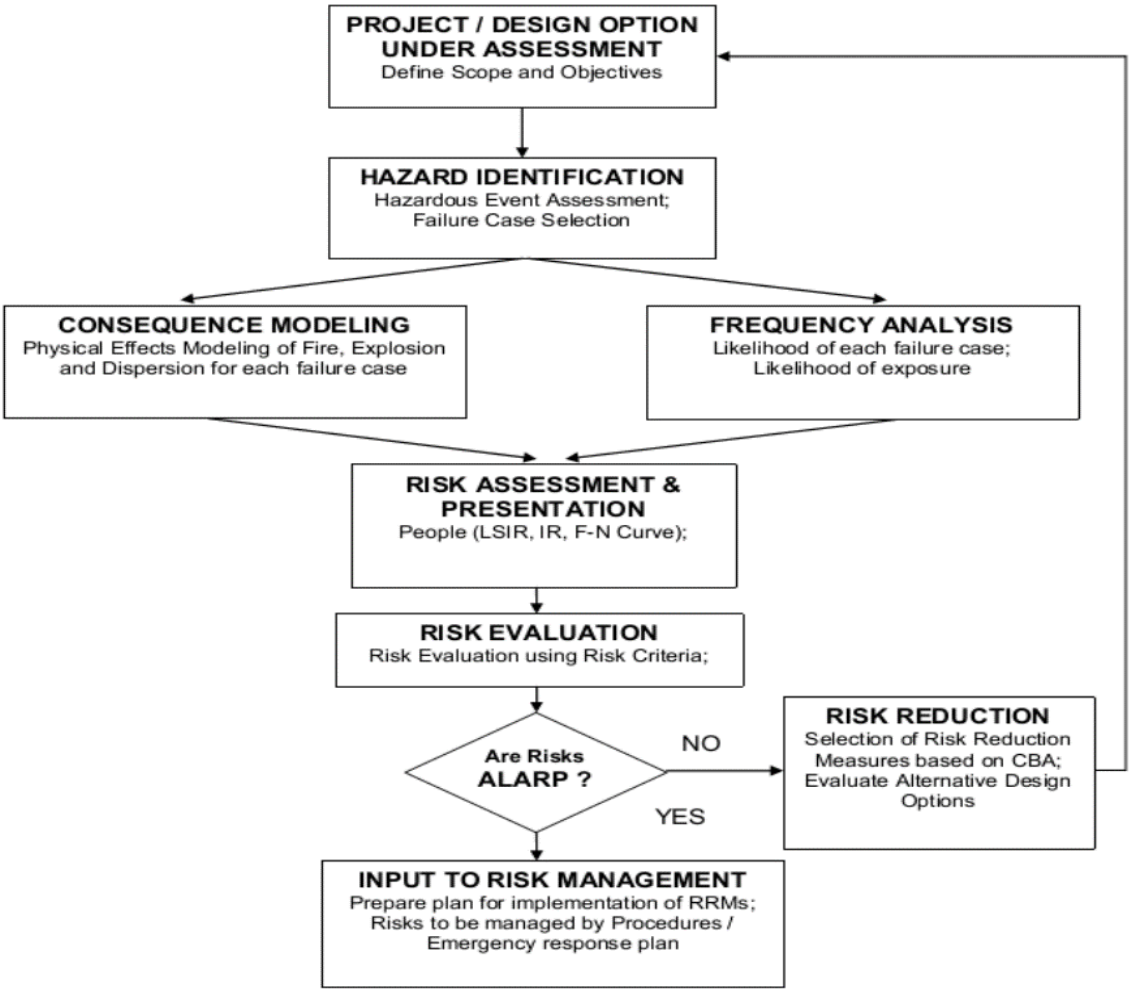
- ✓ Identification of potential major hazard scenarios;

- ✓ Assessment of the likelihood and consequences of identified hazards;
- ✓ Estimation of the impact of identified hazards on personnel; and
- ✓ Assessment of the risks against tolerance criteria.

The Risk Assessment (RA) uses conventional risk assessment techniques as shown in Figure 7.1 and described as follows:

- ✓ Identify the preliminary causes of major accidents associated with the process, and develop a list of representative potential events involving the release of hazardous materials or other events, which could lead to loss of life or damage to infrastructure.
- ✓ Model the possible scale of severity of the physical effects of each identified hazardous event. Predict the criticality of the damage that could be caused and the potential for escalation, developing rule sets and assumptions to form the basis of an analysis of the possible outcomes.
- ✓ For each identified hazard, use appropriate models and data to estimate its frequency, taking into account any site-specific features that may influence the likelihood of the scenarios. Compare the event frequency estimates with historical data to confirm the validity of the model.
- ✓ Combine the predicted consequences of each event with its frequency to estimate the risks to personnel. Assess the Individual Risk (IR) for the facilities.
- ✓ Compare the results of the study with Company Risk Tolerance Criteria to establish whether the operation of the project can be regarded as adequately safe. Consider the risk mitigation provided by other measures such as the gas detection and shutdown system.
- ✓ Propose additional Risk Reduction Measures (RRM).

The methodology is presented pictographically in the following section:



Source: ABC Techno Labs India Pvt. Ltd.

Figure 7.1: Risk Assessment Methodology

7.1.3 Hazard Identification

Hazard scenario development is carried out considering the activities at the facilities and the inherent hazardous properties of the material being handled.

The Hazard Identification looks into all incidents, which could result in possible fatalities. For drilling, such incidents typically include the following:

- Well fluid releases - small, medium and large well fluid releases from exploratory/appraisal drilling wells. Possibilities include blowouts (due to either downhole or surface abnormality or possible cratering (a basin like opening in the Earth surface surrounding a well caused by erupted action of gas, oil or water flowing uncontrolled)) or other incidents involving drilling fluids, leakage from mud degassing stacks/ vents and others- these are the major category and are deliberated later.

- Possibility of dropped objects on the drilling platform due to lifting of heavy equipment including components like draw works, drilling pipe, tubing, drill bits, Kelly, mud equipment, shale shakers, BOP components, power generating equipment and others
- Single fatality occupational incidents such as trips and falls. These are more likely in drilling rigs due to the hazardous nature of operations and general high congestion and large extent of the manual operation involved.
- Structural failure of the drilling rig due to excessive static or rotating loads, earthquake, and design defect, construction defect etc. It may be noted that rotating loads are induced due to the specific rotating actions of the rotary drilling mechanism (Drill string rotated by means of rotary table etc.).
- Loss of containment of fuels (HSD) and consequent pool fire on encountering an ignition source.

The HAZID would select the Scenarios for further modeling in the next sections. The HAZID is derived mainly from incidents in similar drilling installations based on worldwide experience and includes generic data sources.

Table 7.1: Accidents due to types of hazardous events

Type of Hazardous Event	*Specific Accident Events included in RA*
Hydrocarbon Release	• *Uncontrolled Blow out-medium, large, small* • *Release from diesel tanks- Catastrophic failure, medium and small risks*
Occupational accidents	• *Single fatality accidents such as slips, trips, falls, dropped objectives etc.*
Other Hazards during drilling Rig operation	• *Structural collapse of drilling rig due to static or rotating load, fatigue, construction defect, design defect, earthquakes etc* – *Hazards during Installing the Auxiliary Equipment* – *Hazard in Rigging Up the Circulating System* – *Hazards during Setting Up the Rig Floor and Mast or Derrick* – *Hazards During Preparation for Setting Up the Substructure*

Source: Vedanta Limited (Division Cairn Oil & Gas)

7.1.3.1 HYDROCARBON RELEASE

The events of blowouts during drilling are divided in the databases according to the consequences and well control success. Such blow outs can be ignited or un-ignited. Blow outs are uncontrolled sudden expulsions of oil, gas, water or drilling fluids from wells to the surface which result in loss of control of the well.

Sources of hydrocarbon release during the drilling phase include the following:

- Dissolved gas which comes out of solution under reduced pressure often while drilling at near balance or under balance hydrostatically or as trip gas during a round trip to pull the drill string around from the hole. Such sources could include releases at bell nipple and around mud return flow line outlet, shale shakers and active mud pits.
- As a “kick”, which occurs as the down hole formation pressure unexpectedly exceeds the hydrostatic head of the circulating mud column. Significant releases can occur from the vent lines of the mud /gas separator and other locations.
- From residual mud on the surface of the drill pipe being racked in the derrick during the round trip, or on production of coil tubing being withdrawn from the hole, or from core samples laid out for inspection. Usually any liquid hydrocarbon system entering the down hole under normal circumstances are very much diluted by the mud system. However, under conditions of under balanced drilling, the proportion of hydrocarbons in mud returns may be significant with a potential for continuous release.
- Small hydrocarbon release from rotating equipment, pipes and pump work occurring during normal operations/maintenance during drilling. These are not likely to be significant in open derrick or mast structures.
- Possible shallow gas blowout – these may occur at sumps or drainage tanks and be conveyed by vents or drains to areas of potential ignition sources resulting in fire/ explosion.
- Vapour present in oily drainage systems, vents, and ducting.
- Flammable materials used in drilling operations (oil based drilling fluids)- release points could include high pressure mud points, mud degassing equipment, shale shaker, mud pits and active tanks etc.

7.1.3.2 BLOWOUT PREVENTION

If the hydrostatic head exerted by the column of drilling fluid is allowed to drop below the formation pressure then formation fluids will enter the well bore (this is known as a kick) and a potential blowout situation has developed. Blowout means uncontrolled violent escape of hydrocarbon fluids from a well. Blowout followed by ignition, is a major hazard. Major contributors to blowout are:

Primary

- Failure to keep the hole full;
- Too low mud weight;
- Swabbing during trips;
- Lost circulation; and
- Failure of differential fill-up equipment.

Secondary

- Failure to detect and control a kick as quickly as possible;
- Mechanical failure of Blow Out Preventer (BOP);
- Failure to test BOP equipment properly;
- Damage to or failure of wellhead equipment;
- Failure of casing; and
- Failure of formation or cement bond around casing.
- Fast and efficient action by operating personnel in recognizing the above situations and taking precautionary measure can avert a blowout.

❑ ***Presence of Sour Gas (Hydrogen Sulphide-H_2S)***

Presence of Sour Gas (H_2S) in hydrocarbon during blowout of well can pose immediate dangers to life and health at and around the rig area. On ignition, H_2S is converted to Sulfur dioxide (SO_2) which is also highly toxic. Therefore, a safety system should be in place to monitor H_2S.

Hydrogen Sulphide gas (H_2S) is extremely toxic and even very low concentrations can be lethal depending upon the duration of exposure. Additionally it is corrosive and can lead to failure of the drill string or other tubular components.

Important characteristics of H_2S gas are briefed below:

1. H_2S is a toxic colourless gas heavier than air.
2. In concentrations greater than 100 ppm, it causes loss of senses in 3 to 15 minutes and death within 48 hours.
3. The safe concentration for a normal working period without protection is 10 ppm.
4. It has an odour of rotten eggs.
5. In concentration greater than 10 ppm, the olfactory sense to smell the gas is lost, hence need for detectors is apparent.
6. It dissolves in the blood and attacks through the nervous system.
7. It is very irritating for the eyes as it forms sulphurous acid together with water.
8. It attacks the body through the respiratory organs.
9. The Occupational Safety and Health Act (OSHA) sets a 10 ppm ceiling for an (eight) hour continuous exposure (TWA limit), a limit of 15 ppm for short term exposure limit for 15 minutes (STEL) and a peak exposure concentration of 50 ppm for 10 minutes.
10. The best protection is breathing apparatus, with mask covering the whole face and a bottle containing breathing air.
11. H_2S burns with a blue flame to sulphur dioxide which is also dangerous
12. It forms an explosive mixture with air at concentrations from 4% to 46%.
13. Short exposure of high tensile steel to as little as 1 ppm in aqueous solution can cause failures.
14. Concentrations greater than 15 ppm can cause failure to steel harder than Rockwell C-22. High stress levels and corrosive environments accelerate failures.
15. When pH is above 9 and solubility is relatively high, it is readily soluble in mud and especially in oil mud.
16. A 30% hydrogen peroxide solution will neutralize H_2S gas in the mud or 20 gallons of H_2O_2 per 100 barrels of mud. It occurs together with natural gas in all oil provinces of the world.
17. Coughing, eye burning and pain, throat irritation, and sleepiness are observed from exposure to low concentrations of H_2S.

18. Exposure to high concentrations of H_2S results in panting, pallor, cramps, paralysis of the pupil and loss of speech. This is generally followed by immediate loss of consciousness. Death may occur quickly from respiratory and cardiac paralysis.

Concentrations	Symptoms/ Effects
100 ppm	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
Greater than 100 ppm	Loss of smell (olfactory fatigue or paralysis).
500-700 ppm	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000 ppm	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000 ppm	Nearly Instant Death

As per available data, there is no chance of presence of H2S in the hydrocarbon present within block, however, as a hypothetical case, scenario of presence of 3% H2S has been considered for consequence analysis.

7.1.3.3 OTHER HAZARDS DURING DRILLING RIG OPERATIONS

❑ **Hazards During Preparation for Setting Up the Substructure**

Equipment(s) are unloaded and positioned at or near the exact location of drilling point. The substructure is assembled, pinned together, leveled, and made ready for other rig components on the floor. Equipping the cellar begins but can be done throughout the rigging up process. This includes welding on a drilling nipple to the conductor pipe and attaching a flow line.

Potential Hazards:

- Pinched fingers when assembling equipment.
- Burns from cutting and welding on the drilling nipple.
- Temporary eye irritation from welding light flash.
- Falling from heights.

❑ **Hazards during Setting Up the Rig Floor and Mast or Derrick**

Once the substructure is set in place, the process of setting up the rig floor begins by installing stairways and guardrails to allow access to the rig floor. Then, the draw works is set in place and secured to the substructure. On mechanical rigs, the engines are set in place and the compound and associated equipment connected to the draw works. On electric rigs, the electric cables (lines) are strung to the draw works.

The bottom of the mast is raised to the rig floor and pinned in place. The crown section is then raised into place on the derrick stand. The "A-legs" are raised and pinned into place. The monkey board is pinned in place on the mast and all lines and cables are laid out to prevent tangling when the mast is raised. A thorough inspection of the mast should be made before raising the mast/derrick. The mast is now ready to be raised. The engines are started, and the drilling line is spooled onto the draw works drum. Once the mast has been raised and pinned, the remaining floor equipment can be set into place. If the rig has safety guy lines, they must be attached to the anchors and properly tensioned prior to continuing the rigging up process. A derrick emergency escape device is installed on the mast.

Potential Hazards:

- Falling or tripping during rigging up;
- Falling from rig floor;
- Being struck by swinging equipment;
- Being struck by falling tools;
- Being crushed or struck by equipment due to failure or overloading of hoisting equipment;
- Getting entangled in lines during rising of the derrick or mast;
- Failure to properly install derrick emergency escape device; etc.

❑ **Hazard in Rigging Up the Circulating System**

While one crew finishes preparing the rig floor, another crew might be rigging up the circulating system. The mud tanks and mud pumps are set into the pre-determined location. The mud lines are then connected and electric cords are strung.

Potential Hazards:

- Being struck by or crushed by equipment being set into place;
- Getting caught in pinch points;
- Being struck by crane, load, truck or forklift tipping;
- Being struck by hammer when connecting mud line unions; etc

❑ **Hazards during Installing the Auxiliary Equipment**

All remaining drilling and auxiliary equipment must be set into place and installed where needed. The catwalk and pipe racks are positioned and the pipe and drill collars are set on the racks.

Potential Hazards:

- Getting struck or pinched by, or caught in between, tubulars being loaded onto racks.
- Having feet pinched or crushed when setting up the pipe racks and catwalk.

7.1.4 CONSEQUENCE ANALYSIS

Consequence analysis involves the calculation of the initial "release rate" and then predicting the consequence of the release through computer modeling- it forms an important ingredient in the RA approach. Consequence analysis is a complex procedure involving numerous calculations. It must also be noted that a single starting incident could have numerous outcomes depending upon factors such as escalation, ignition and others. The various factors of importance in this drilling rig study with respect to consequence analysis are described below.

Table 7.2: List of Isolatable Sections

IS	Scenario
IS 01	From Well Fluid from Well to Inlet of Heater Separator
IS 02	Heater Treater Separator – Oil Case
IS 03	Oil from Heater Treater Separator to inlet of Oil Storage Tanks including coaleser separator
IS 04	From XSV of storage tank inlet to pump inlet including oil storage tank
IS 05	From Oil Transfer pump outlet to Road tanker loading
IS 06	Road Tanker Failure
IS 07	Diesel Storage Tank
IS 08	Fuel Gas System
IS 09	Flare System

Source: ABC Techno Labs India Pvt. Ltd.

Note 1:

The Test Separator, Flare System including associated pumps, KODs are not included as the details (P&IDs, Operating Pressure, Operating Temperature, Composition, Flowrate, Flare datasheet, etc) are not available during the execution of the project.

However, the same will be included in the next revision of the report.

Depending on the type of liquid handled and process conditions, one or more of the following potential hazards/consequences could be encountered due to loss of containment of hydrocarbons:

- ✓ Un-ignited release;
- ✓ Jet Fire;
- ✓ Pool Fire;
- ✓ Flash Fire;
- ✓ Vapour Cloud Explosion; and
- ✓ Toxic Impact (Not applicable for this project)

7.1.4.1 UN-IGNITED GAS RELEASE / DISPERSION

A vapour cloud may be formed when a vaporizing liquid is released for an extended duration. If the gas cloud does not immediately ignite, it disperses based on the prevalent wind direction, speed and stability category (i.e. degree of turbulence).

The cloud dispersion simulation is carried out to provide the distance (from the leak) at which the concentration of flammable material falls below the Lower Flammability Limit (LFL).

7.1.4.2 JET FIRE

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from Piping and Tanks.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak till the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

Source term modelling has been conducted for each identified study area at all the locations at the full stream operating pressure to determine the initial release rate. The release rates and material properties were used to calculate the flame length and distance to relevant heat radiation levels.

Two models are available for jet fire modelling in PHAST V8.2 – the cone model and the API-RP 521 model, of which the cone model is considered to be more conservative, and presents the jet fire as a tilted cone frustum, as opposed to a banana shaped plume in the API-RP 521 model, i.e. tapered at the end and bent by the wind. Thus, the cone model has been selected for jet-fire modelling.

The primary hazard associated with jet fires is thermal radiation and potential for flame impingement on adjacent pipelines/equipment, resulting in escalation. High pressure releases have the potential to cover large areas due to its relatively large flame length. However, the effects of escalation are minimized if the flame length reduces to less than the separation distance between other equipment and the jet fire source.

7.1.4.3 POOL FIRES

A liquid pool is formed during a prolonged leakage if the rate of leakage exceeds the rate of vaporization. On ignition, this would result in a pool fire whose size / radius would depend on the mass flow rate, ambient temperature, and heat of vaporization of material released, vapour pressure, duration of discharge and effects of containment or dykes.

The pool fire could cause damage to equipment or injury / fatality to personnel due to thermal radiation effects.

A pool fire is not envisaged for liquid systems which are highly pressurized. Any leak or rupture would result in a pressurized release leading to a liquid jet fire or flash fire.

7.1.4.4 FLASH FIRE

The vapour/gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and ½ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

7.1.4.5 VAPOUR CLOUD EXPLOSION

The magnitude of the vapour cloud explosion is dependent on the size of the gas cloud that has formed and the degree of congestion in the area, as these determine the acceleration of the flame front. The TNO GAMES model is used for modelling of vapour cloud explosions, as the model incorporates the characteristics of the explosion, such as the type of fuel, its reactivity, the effect of obstacles in the congested region.

7.1.4.6 TOXIC EFFECTS

There is no toxic impact in this project as there are no toxic materials handled.

7.1.4.7 CONSEQUENCE IMPACT CRITERIA

The damage potential associated with the various hazardous outcomes described above is assessed based on pre-defined impairment criteria for losses.

Estimate of damage or impact caused due to thermal radiation, explosion overpressure and toxic effects is generally based on the published literature on the subject. Probit relations are used for these calculations. The actual potential consequences from these likely impacts can then be visualized by superimposing the damage effect zones on the proposed layouts and identifying the elements within the project which might be adversely affected, should one or more hazards materialize in practice. The damage criteria used in the present study is described in the following sections.

7.1.4.8 THERMAL DAMAGE/ RADIATION DAMAGE

As per OGP-14;

4.73 kW/m2	*Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing. Corresponds to of painful burns and blistering after 20 second exposure (0% lethality)*
6.31 kW/m2	*Indicative of second degree burns after 20 second exposure (1% fatality)*
12.5 kW/m2	*Indicative of piloted ignition for susceptible structures (50% fatality)*
37.5 kW/m2	*Indicative of total asset loss (100% fatality)*

Hence, following heat radiation levels are considered to determine physical effects of hazard events:

4.73 kW/m2;

6.31 kW/m2,

12.5 kW/m2,

37.5 kW/m2

7.1.4.9 FLASH FIRE

The consequence distances should be identified for the following Lower Explosive Limit:

- 50 % Lower Explosive Limit
- 100 % Lower Explosive Limit

7.1.4.10 EXPLOSION

Blast peak overpressure from explosion for buildings should not exceed the following levels provided in Table below. Internationally recognized and globally accepted TNO Multi energy model was used for the explosion modeling for this Project

Table 7.3: Overpressure level criteria

Level of Concern	Type of Damage
0.02068 bar	"Safe distance" (probability 0.95 of no serious damage1 below this value); projectile limit; some damage to house ceilings; 10% window glass broken.
0.07 bar	General buildings, offices
0.2068 bar	Partial collapse of wells, concreate Block wells, not reinforced, shattered
1 bar	Range for 1-99% fatalities among exposed population due to direct blast effects

Hence, following over pressure levels are considered to determine physical effects of hazard events:

- 0.02068 bar
- 0.07 bar
- 0.1379 bar
- 0.2068 bar
- 1 bar

7.1.4.11 TOXIC GAS

No toxic gas dispersion envisaged in this project.

7.1.4.12 CONSEQUENCE ANALYSIS AND CALCULATIONS

- **Hole Size Distribution**

For each isolatable section and its study areas, a range of leaks have been considered for the assessment of hydrocarbon hazards arising from facility is described in section, these leaks are defined on the basis of hole sizes.

- **Meteorological Data**

The consequences of material released being toxic and flammable are largely dependent on the prevailing weather conditions. For the assessment of various scenarios involving release of toxic or flammable materials, the most important meteorological parameters are those that affect the atmospheric dispersion of the leaking material. The crucial variables are wind direction, wind speed, atmospheric stability and temperature. Rainfall does not have any direct bearing on the results of the risk analysis; however, it can have beneficial effects by absorption/washout of released materials. Actual behavior of any release would largely depend on prevailing weather condition at the time of release.

- **Atmospheric Stability Classes**

The tendency of the atmosphere to resist or enhance vertical motion and thus turbulence is termed as stability. Stability is related to both the change of temperature with height (the lapse rate) driven by the boundary layer energy budget, and wind speed together with surface characteristics (roughness).

A neutral atmosphere neither enhances nor inhibits mechanical turbulence. An unstable atmosphere enhances turbulence, whereas a stable atmosphere inhibits mechanical turbulence.

Stability classes are defined for different meteorological situations, characterized by wind speed and solar radiation (during the day) and cloud cover during the night. The so called Pasquill-Turner stability classes' dispersion estimates include six (6) stability classes as below:

A – Very Unstable B – Unstable C – Slightly Unstable

D – Neutral E – Stable F–Very Stable

For the study purpose, following weather conditions are taken forward for modelling purposes:

- 2F - F stability class and wind speed of 2m/sec
- 5D - D stability class and wind speed of 5m/sec

❑ **Release Rates**

The release rates were determined based on the release size and the process conditions i.e. temperature and pressure. Depending on the operating conditions, the release state of the fluid could be liquid, gas or two-phase. The release rates were estimated using the software. The release rates and the phase would give an indication of severity of the leak and influence the flammable and toxic impacts.

A. Jet Fire Radiation Distances

The Jet Fire Radiation distances are not generated for the scenarios considered in this project.

Table 7.4: Jet Fire Radiation Distances

IS No	Scenario	Weather	4.73 kW/m2 [m]	6.31 kW/m2 [m]	12.5 kW/m2 [m]	37.5 kW/m2 [m]
IS 01	5mm	1.5F	15.76	14.75	12.82	10.61
		5D	13.79	12.77	10.83	8.68
	25mm	1.5F	65.03	60.43	51.46	40.9
		5D	57.53	52.91	44	33.91
	100mm	1.5F	223.2	206.7	174.6	137.4
		5D	188.6	173.3	143.6	109.9
	FBR	1.5F	319.7	295.9	249.6	195.9
		5D	260.4	239.4	198.8	152.4
IS 02	5mm	1.5F	15.64	14.65	12.73	10.54
		5D	13.69	12.68	10.75	8.619
	25mm	1.5F	65.03	60.43	51.46	40.9
		5D	57.53	52.91	44	33.91
	100mm	1.5F	223.2	206.7	174.6	137.4
		5D	188.6	173.3	143.6	109.9
	FBR	1.5F	319.7	295.9	249.6	195.9
		5D	260.4	239.4	198.8	152.4
IS 03	5mm	1.5F	15.64	14.65	12.73	10.54
		5D	13.69	12.68	10.75	8.619
	25mm	1.5F	79.26	73.68	62.87	50.38
		5D	71.19	65.38	54.18	41.59
	100mm	1.5F	223.2	206.7	174.6	137.4
		5D	188.6	173.3	143.6	109.9
	FBR	1.5F	319.7	295.9	249.6	195.9
		5D	260.4	239.4	198.8	152.4
IS 04	5mm	1.5F	15.64	14.65	12.73	10.54
		5D	13.69	12.68	10.75	8.619
	25mm	1.5F	65.03	60.43	51.46	40.9
		5D	57.53	52.91	44	33.91

IS No	Scenario	Weather	4.73 kW/m2 [m]	6.31 kW/m2 [m]	12.5 kW/m2 [m]	37.5 kW/m2 [m]
	50mm	1.5F	120.5	111.7	94.73	74.85
		5D	107	98.26	81.33	62.21
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
IS 05	5mm	1.5F	18.37	17.19	14.92	12.37
		5D	16.26	15.03	12.69	10.1
	25mm	1.5F	74.78	69.51	59.28	47.41
		5D	66.93	61.47	50.97	39.16
	100mm	1.5F	257.2	238.3	201.7	159.6
		5D	212.2	195.1	161.9	124.1
	FBR	1.5F	363.8	337.1	285.2	225.5
		5D	293.2	269.8	224.3	172.3
IS 06	10mm	1.5F	33.02	30.79	26.46	21.62
		5D	29.4	27.09	22.63	17.71
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
IS 07	5mm	1.5F	1.162	1.162	1.162	NR
		5D	1.119	1.119	1.119	1.119
	25mm	1.5F	1.567	1.567	1.567	NR
		5D	1.431	1.431	1.431	1.431
	50mm	1.5F	1.791	1.791	1.791	NR
		5D	1.631	1.631	1.631	1.631
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
IS 08	5mm	1.5F	NR	NR	NR	NR
		5D	1.254	1.053	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	1.254	1.053	NR	NR
	100mm	1.5F	11.89	4.254	NR	NR
		5D	20.7	17.1	7.255	NR
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
IS 09	5mm	1.5F	NR	NR	NR	NR
		5D	1.254	NR	NR	1.053
	25mm	1.5F	NR	NR	NR	NR
		5D	1.254	NR	NR	1.053
	100mm	1.5F	11.89	NR	NR	4.254
		5D	20.7	7.255	NR	17.1
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR

B. Pool Fire Radiation Distances

The Pool Fire Radiation Distances is provided below;

Table 7.5: Pool Fire Radiation Distances

IS No	Scenario	Weather	4.73 kW/m2 [m]	6.31 kW/m2 [m]	12.5 kW/m2 [m]	37.5 kW/m2 [m]
IS 01	5mm	1.5F	NR	NR	NR	19.35
		5D	NR	NR	NR	NR
	25mm	1.5F	32.94	30.78	25.96	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	67.58	58.6	44.85	NR
		5D	83.55	71.63	49.76	NR
	FBR	1.5F	73.49	64.01	49.86	NR
		5D	91.39	78.1	55.11	NR
IS 02	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	32.94	30.78	25.96	19.35
		5D	NR	NR	NR	NR
	100mm	1.5F	52.55	48.41	38.93	31.02
		5D	59.84	56.95	48.04	35.22
	FBR	1.5F	57.15	52.75	42.75	35.16
		5D	65.84	62.64	52.06	39.78
IS 03	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	52.55	48.41	38.93	31.02
		5D	59.84	56.95	48.04	35.22
	FBR	1.5F	57.15	52.75	42.75	35.16
		5D	65.84	62.64	52.06	39.78
IS 04	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	39.24	35.99	28.6	20.35
		5D	NR	NR	NR	NR
	50mm	1.5F	56.97	49.47	36.53	NR
		5D	65.93	60.53	42.16	NR
	CR	1.5F	113.1	91.08	62.89	NR
		5D	142.5	111.3	63.37	NR
IS 05	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	62.96	59.54	51.73	43.37
		5D	70.36	67.95	63.59	52.8
	FBR	1.5F	71.64	67.7	58.66	50.54
		5D	83.33	80.7	73.67	60.35

IS No	Scenario	Weather	4.73 kW/m2 [m]	6.31 kW/m2 [m]	12.5 kW/m2 [m]	37.5 kW/m2 [m]
IS 06	10mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	CR	1.5F	51.01	40.54	25.44	NR
		5D	69.56	53.99	28.96	NR
IS 07	5mm	1.5F	15.36	13.91	11.22	7.089
		5D	16.12	14.92	12.55	8.956
	25mm	1.5F	23.13	20.49	14.77	6.556
		5D	24.95	22.53	17.93	7.467
	50mm	1.5F	23.13	20.49	14.77	6.557
		5D	24.95	22.53	17.93	7.467
	CR	1.5F	23.13	20.49	14.77	6.557
		5D	24.96	22.54	17.93	7.469
IS 08	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
IS 09	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	CR	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR

C. Flash Fire Radiation Distances

Flammable Dispersion Distances are provided below;

Table 7.6: Flammable Dispersion Distances

IS No	Scenario	Weather	LFL [m]	LFL Fraction [m]
IS 01	5mm	1.5F	6.465	8.269
		5D	5.613	8.337
	25mm	1.5F	76.63	123.3
		5D	50.25	81.45

IS No	Scenario	Weather	LFL [m]	LFL Fraction [m]
	100mm	1.5F	182.9	287.8
		5D	197.1	275.7
	FBR	1.5F	156.4	210.8
		5D	255.5	338.1
IS 02	5mm	1.5F	6.424	8.345
		5D	5.522	8.26
	25mm	1.5F	76.63	123.3
		5D	50.25	81.45
	100mm	1.5F	83.34	99.62
		5D	134.8	174.1
	FBR	1.5F	79.41	106.6
		5D	128.2	166.9
IS 03	5mm	1.5F	6.424	8.345
		5D	5.522	8.26
	25mm	1.5F	85.34	140.9
		5D	73.3	113.8
	100mm	1.5F	83.34	99.62
		5D	134.8	174.1
	FBR	1.5F	79.41	106.6
		5D	128.2	166.9
IS 04	5mm	1.5F	6.424	8.345
		5D	5.522	8.26
	25mm	1.5F	86.74	160.1
		5D	50.25	81.45
	50mm	1.5F	219.5	353
		5D	112.2	160.9
	CR	1.5F	21.14	137.6
		5D	87.73	125.9
IS 05	5mm	1.5F	8.449	12.36
		5D	6.88	11.05
	25mm	1.5F	87	144.2
		5D	66.05	103.3
	100mm	1.5F	98.65	124.7
		5D	158.1	204.8
	FBR	1.5F	120.9	133
		5D	143.7	187.4
IS 06	10mm	1.5F	23.01	51.29
		5D	15.75	29.88
	CR	1.5F	59.2	73.21

IS No	Scenario	Weather	LFL [m]	LFL Fraction [m]
		5D	124.3	174.7
IS 07	5mm	1.5F	2.304	2.628
		5D	2.676	2.745
	25mm	1.5F	2.886	2.886
		5D	4.39	4.723
	50mm	1.5F	3.549	3.862
		5D	4.368	4.368
	CR	1.5F	7.993	7.994
		5D	10.06	10.06
IS 08	5mm	1.5F	0.005	0.006
		5D	0.005	0.006
	25mm	1.5F	0.005	0.006
		5D	0.005	0.006
	100mm	1.5F	0.124	0.127
		5D	0.116	0.122
	FBR	1.5F	2.002	2.634
		5D	2.115	3.214
IS 09	5mm	1.5F	0.005	0.006
		5D	0.005	0.006
	25mm	1.5F	0.005	0.006
		5D	0.005	0.006
	100mm	1.5F	0.124	0.127
		5D	0.116	0.122
	FBR	1.5F	2.002	2.634
		5D	2.115	3.214

Source: ABC Techno Labs India Pvt. Ltd.

D. Toxic Dispersion

There is no toxic hazard in the facility.

E. Vapour Cloud Explosion

A vapour cloud explosion involves a flame moving through a fuel-air mixture. In absence of turbulence generation, the cloud will burn as a flash fire without generation of high over pressure. However significant turbulence can be generated by obstacle encountered by a flame as it is propagated through the vapour cloud in obstructed region. It is that explosion that occurs in the presence of obstacle that can generate overpressure with potential for extensive damage.

In order to model vapour cloud explosion, the Obstructed Region Explosion Model available in SAFETI 8.2 has been used and a brief overview has been provided below.

OREM in PHAST would enable a user to model the blast effects from vapour clouds dispersing through regions containing obstacles.

Explosions in Obstructed Regions have been modeled in the Multi-Energy (ME) Model.

ME Obstruction set has been used for defining Obstructed Regions and it consider the following:

- Degree of expansion (2D/ 3D);
- Volume (Blockage ratio):
- Surface of area of obstruction source and Flame path length

Late Explosion Overpressure Distances is provided below;

Table 7.7: Late Explosion Overpressure Distances

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
IS 01	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			1	NR
	FBR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
IS 02	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	FBR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			0.2068	NR
			1	NR
IS 03	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	FBR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
IS 04	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	50mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	CR	1.5F	0.02068	555.2
			0.07	357.6
			0.2068	302.2
			1	274.1
		5D	0.02068	321.1
			0.07	184
			0.2068	150.7
			1	132.2
IS 05	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	FBR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
IS 06	10mm	1.5F	0.02068	158.2
			0.07	111.8
			0.2068	95.67
			1	86.23
		5D	0.02068	81.6
			0.07	56.92
			0.2068	48.34
			1	43.31
	CR	1.5F	0.02068	452.2
			0.07	272.5
			0.2068	214.8
			1	181.8
		5D	0.02068	422.9
			0.07	242.6
			0.2068	194
			1	179.1
IS 07	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	50mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	CR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
IS 08	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	CR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
IS 09	5mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	25mm	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	100mm	1.5F	0.02068	NR

IS No	Scenario	Weather	Overpressure (bar)	Distance [m]
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
	CR	1.5F	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR
		5D	0.02068	NR
			0.07	NR
			0.2068	NR
			1	NR

Source: ABC Techno Labs India Pvt. Ltd.

F. Fire Ball

Fire ball distances are provided below;

IS No	Scenario	Weather	4.73 kW/m2 [m]	6.31 kW/m2 [m]	12.5 kW/m2 [m]	37.5 kW/m2 [m]
IS 08	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	18.44	16.01	11.39	6.336
		5D	18.44	16.01	11.39	6.336
	FBR	1.5F	18.44	16.01	11.39	6.336
		5D	18.44	16.01	11.39	6.336
IS 09	5mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	25mm	1.5F	NR	NR	NR	NR
		5D	NR	NR	NR	NR
	100mm	1.5F	18.44	16.01	11.39	6.336
		5D	18.44	16.01	11.39	6.336
	FBR	1.5F	18.44	16.01	11.39	6.336
		5D	18.44	16.01	11.39	6.336

Source: ABC Techno Labs India Pvt. Ltd.

7.1.5 FAILURE FREQUENCY ANALYSIS

As a part of the process of determining risk the failure frequencies of the hazard events are calculated. Component failures are the primary initiating events for most hazards and accidents and there are various potential causes for component failure resulting in sources of leakage, which may release contained fluids to the atmosphere. Failure scenarios can range from small gasket leaks in a flange joint to rupture resulting in catastrophic failure of a pipeline section. Major failure modes associated with different operational areas are listed below:

- *Failure of weld joints / gaskets (sample points, instrument connections etc.);*
- *Valve gland leakages; and*
- *Leaks/ full bore rupture of the pipe work.*
- *Tank Rupture*

These part counts are combined with historical data from the OGP database to give an overall potential leak frequency for each isolatable section which are then divided into small, medium, large and full bore as described in the methodology section of this report.

The base failure frequency for Valves, Flanges and Pumps are sourced from OGP 434-1.

7.1.5.1 CALCULATION OF INDIVIDUAL & SOCIETAL RISK

Individual Risk or IR represents the geographical distribution of risk to any individual.

Societal Risk is representing the risk the project poses to society as a whole. The Societal Risk or Group risk (F-N) curves indicate the cumulative frequency (F) of (N) number of fatalities. Society is typically not willing to accept industrial installations that result in many fatalities, even with a low frequency rate!

The estimation of risks in the software is done through estimation of “risks” attributed to each failure case by determining the impact in terms of fatalities. In this step, the hazard or effect zone information, ignition source, population distribution, meteorological data and other relevant details are combined to determine risks.

In order to estimate risks (IR or SR), the number of fatalities for each incident outcome case is calculated and the frequencies of outcomes with equal fatalities summed up.

After determination of potential sources of accidents and their zone of effect, the risk is quantified in terms of likelihood of fatalities due to these accidents by combining the frequency and severity (consequences). The commonly used risk indicators for onshore facilities are:

- Individual Risk per Annum (IRPA),
- Potential Loss of Life (PLL) and
- Societal Risk for the facilities

The risk at any particular location is expressed as Location Specific Individual Risk (LSIR). The LSIR is then combined with personnel occupancy levels to obtain the fatality risk expressed as individual risk. The estimated risk levels are assessed against Company Individual risk tolerable criteria for existing facilities to establish whether the project facilities can be regarded as in compliance with them.

❑ **Individual Risk**

Individual risk is defined as the frequency at which a named individual would be killed as a result of exposure to a hazard.

Individual Risk = LSIR X Occupancy

Where,

'Occupancy' is the proportion of time the individual is exposed to the hazard.

❑ **Societal Risk**

Assessment of societal risks is even more important than assessment of individual risk because they involve the likelihood of multiple fatalities. Societal risk is the risk to any person or group of persons who are not connected to project facilities and are outside the facility fence line.

❑ **F-N Curve**

It is helpful to consider group risk in the demonstration that risks are ALARP. This allows consideration to be given to events, which, although low in frequency, may cause multiple injuries or fatalities. Group risk can be presented in the form of a plot of cumulative frequency versus number of fatalities (F-N curve).

F = frequency (experienced or predicted)

N = no. of multiple fatalities.

'N' includes indirect deaths caused as a result of the main event occurring and can therefore be difficult to predict e.g. many people may die years after exposure to a toxic chemical.

7.1.5.2 EVENT TREE ANALYSIS

This task involves a probabilistic risk assessment to determine the probability of occurrence of a hazardous outcome following a failure event e.g. the probability of occurrence of gas cloud, fire or explosion event following a leak.

Operational probability is considered as 1 as the facility is in operation continuously.

Event Trees for small, medium, large and rupture release sizes for the present study have been used for RA. Each route in the tree has a corresponding impact event tree, which contains probabilities for immediate ignition for obtaining different types of flammable effects and for dispersion of the un-ignited releases. Total ignition probabilities have been sourced from the IP database.

The potential for ignition mainly depends upon the size and composition of a given release and the number of potential ignition sources available. Electrical equipment in hazardous areas is usually designed such that it will not present a potential ignition source (e.g. Intrinsically Safe). As such, in most cases (excluding hot surfaces or auto ignition of gas due to static charge) a fault would have to be present in an item of equipment before it becomes a potential ignition source.

However, should a flammable mixture be of sufficient size, then non-rated equipment outside the hazardous area could provide source of ignition. The Event Tree adopted for this project is provided in the following Figures;

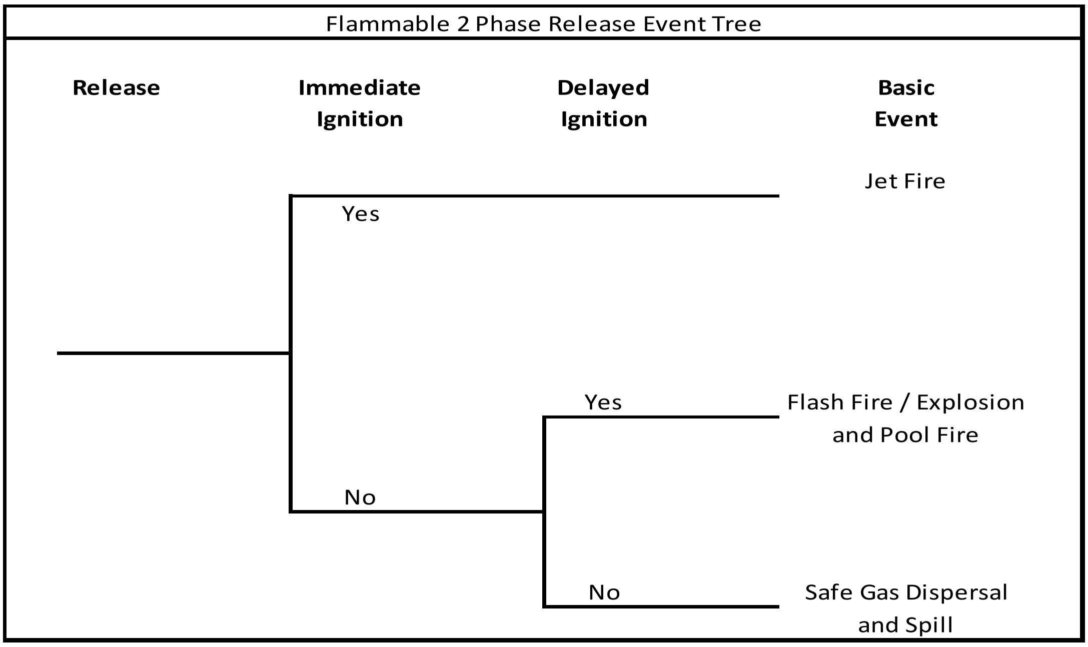


Figure 7.5: Flammable 2 Phase Release Event Tree

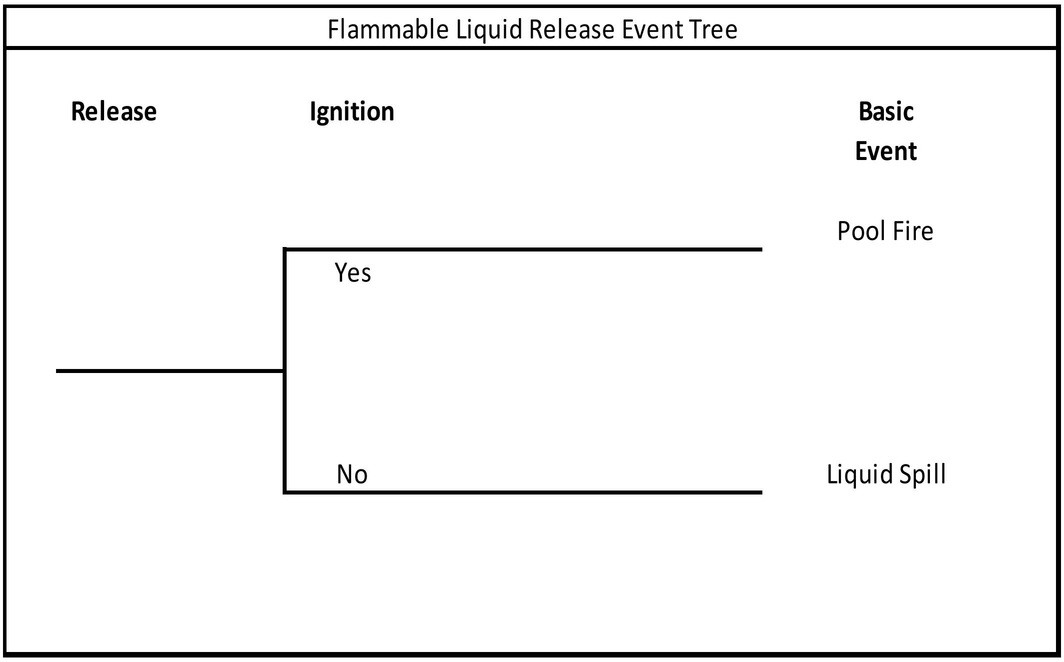


Figure 7.6: Flammable Liquid Release Event Tree

As described above, other potential ignition sources may be hot surfaces, sparks caused by mechanical impact or static charge auto ignition due to high pressure gas escaping through an orifice.

7.1.5.3 Comparison to Risk Acceptance Criteria

This penultimate step compares the estimated risk with respect to the Company's internal risk acceptability criteria or specific legislative or regulatory (as applicable in the country of operation) risk acceptability criteria. In this step, the risk "band" is determined- typically, the project risk band is determined to be negligible, acceptable, not acceptable are the risk assessment stage determines whether the risks are "Broadly Acceptable", "Intolerable" or "Tolerable if ALARP".

Vedanta Limited (Division: Cairn Oil & Gas) Risk Acceptability Criteria

Vedanta Limited (Division: Cairn Oil & Gas) risk acceptability criteria are derived from interpretation of the risk acceptability criteria published by UK HSE-92 and are applied when assessing the tolerability of risk to persons for Vedanta Limited (Division: Cairn Oil & Gas) facilities, sites, combined operations or activities. It broadly indicates as follows:

- Individual risk to any worker above 10^{-3} per annum shall be considered intolerable and fundamental risk reduction improvements are required.
- Individual risk below 10^{-3} for but above 10^{-6} per annum for any worker shall be considered tolerable if it can be demonstrated that the risks are As Low As Reasonably Practicable (ALARP).
- Individual risk below 10^{-6} per annum for any worker shall be considered as broadly acceptable and no further improvements are considered necessary provided documented control measures are in place and maintained.
- Individual risk to any member of the general public as a result of Vedanta Limited (Division: Cairn Oil & Gas) Businesses activities shall be considered as intolerable if greater than10^{-4} per annum, broadly acceptable if less than 10^{-6} per annum and shall be reduced to As Low As Reasonably Practicable (ALARP) between these limits.
- For new facilities, Vedanta Limited (Division: Cairn Oil & Gas) shall strive to achieve lower risks compared with that typical for existing facilities, down at least to an individual risk to any worker of 10^{-4} per annum, by the appropriate use of best practice including technology and management techniques.
- For existing facilities, higher risk levels may be tolerated provided that they are As Low As Reasonably Practicable (ALARP) and meet the minimum standards given herein. As facilities under Vedanta Limited (Division: Cairn Oil & Gas) expansion may

be considered as "new" facilities; it is proposed that individual risk to any worker above 10^{-4} per annum shall be considered intolerable.

Individual Risk Criteria (IR)

The Vedanta Limited (Division: Cairn Oil & Gas) Individual Risk Criteria is provided below.

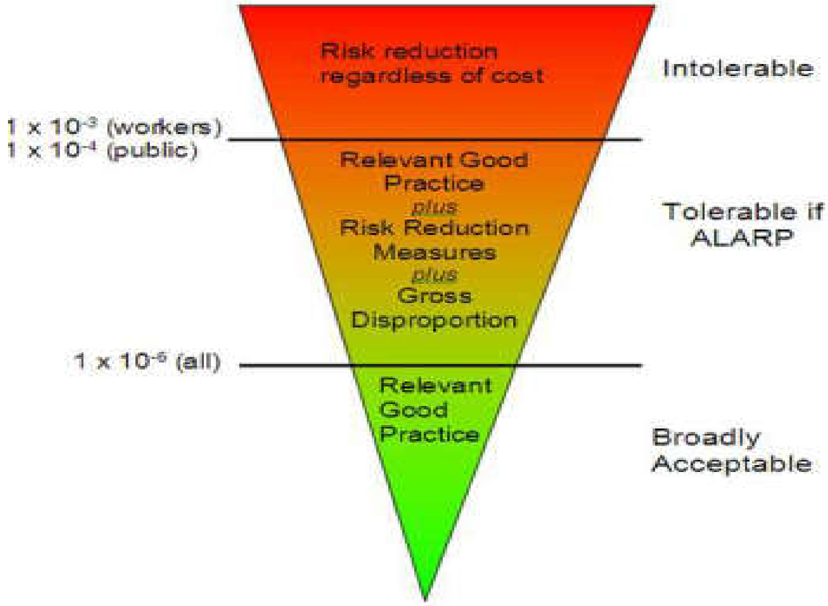


Figure 7.7: Individual Risk Criteria

Societal Risk Criteria

Societal risk criteria for Vedanta are used to limit the risks to a group of people and it is expressed as an F-N Curve.

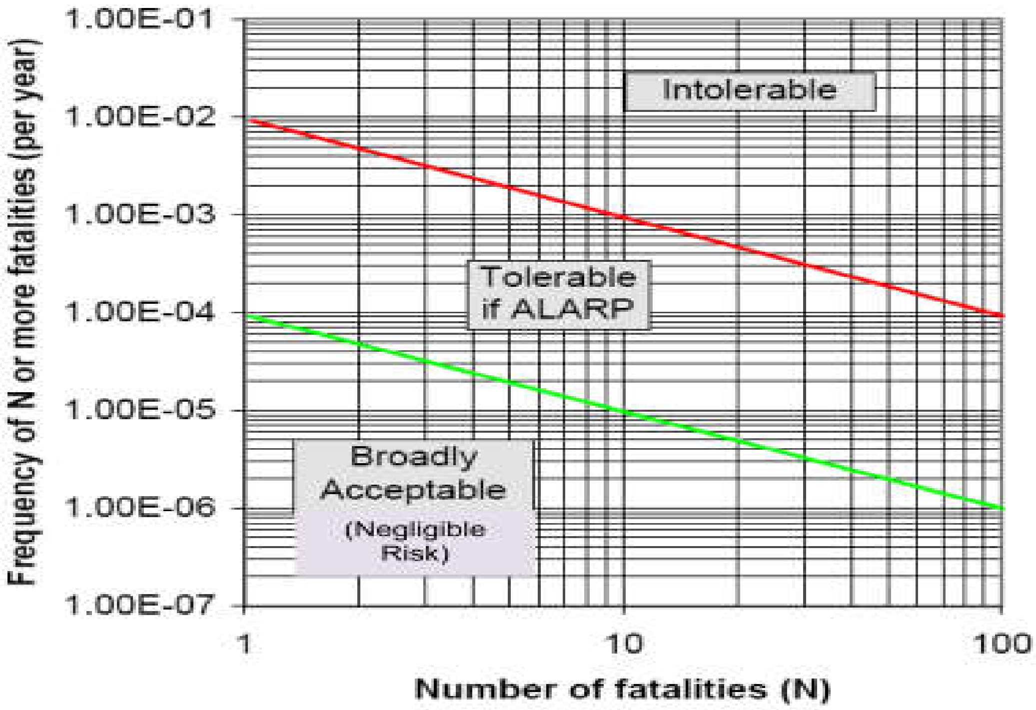


Figure 7.8: Societal Risk Criteria

7.1.5.4 FAILURE FREQUENCY ANALYSIS

As a part of the process of determining risk the failure frequencies of the hazard events are calculated. Component failures are the primary initiating events for most hazards and accidents and there are various potential causes for component failure resulting in sources of leakage, which may release contained fluids to the atmosphere. Failure scenarios can range from small gasket leaks in a flange joint to rupture resulting in catastrophic failure of a pipeline section. Major failure modes associated with different operational areas are listed below:

- Failure of weld joints / gaskets (sample points, instrument connections etc.);
- Valve gland leakages; and
- Leaks/ full bore rupture of the pipe work.
- Tank Rupture

These part counts are combined with historical data from the OGP database to give an overall potential leak frequency for each isolatable section which are then divided into small, medium, large and full bore as described in the methodology section of this report.

The base failure frequency for Valves, Flanges and Pumps are sourced from OGP 434-1.

7.1.5.5 Ignition Probabilities

The potential for ignition mainly depends upon the size and composition of a given release and the number of potential ignition sources available. Electrical equipment in hazardous areas is usually designed such that it will not present a potential ignition source (e.g. flameproof/ intrinsically safe). As such, in most cases (excluding hot surfaces or auto ignition of gas due to static charge) a fault would have to be present in an item of equipment before it becomes a potential ignition source.

However, should a flammable mixture be of sufficient size, then non-rated equipment outside the hazardous area could provide a source of ignition. Other potential ignition sources may be hot surfaces such as heaters, sparks caused by mechanical impact or static charge auto ignition due to high pressure gas escaping through an orifice.

Ignition Probabilities used for the RA study has been taken from Institute of Petroleum Database. The various ignition probabilities have been calculated based on the release rate of each identified scenarios.

The following Look-Up Curves from OGP 434-6 has been used to calculate the Ignition Probability;

This RA Study as per OGP 434-6 has considered immediate ignition probability as 0.001 and it is independent of the release rate. The delayed ignition probability is calculated based on the Total ignition probability taken from the Look Up Curve and Immediate ignition probability.

7.1.6 Risk Estimation

The individual risk levels to personnel and potential loss of life levels at each study area were calculated by combining the consequences and frequencies of the accident scenarios; in accordance with the Company Risk Tolerable Criteria as described in earlier section. All the hazard scenarios that have the potential to impact these areas were included in the risk assessment.

7.1.6.1 Location Specific Individual Risk

The LSIR was estimated based on component failure frequencies and event probability for release scenarios. Note that the LSIR levels represent the cumulative risk from all the major accident events at the project facilities without taking into account personnel exposure factor, vulnerability and probability of escape. The overall Location Specific Individual Risk contours and FN Curve are developed considering all scenarios pertaining to all Isolatable Sections and are provided in Sections below.

The LSIR levels at different locations are provided in the Table below.

Table 7.8: LSIR level at different locations

Location	Individual Risk Ranking values
Diesel Storage area	3.94 E-05
Oil Tank area	2.034 E-04
Process area	1.87 E-04
Rig area	1.731 E-05
Tanker area	9.329 E-05
Toilet Block	1.137 E-06

The LSIR contour is provided in the below Figure below.

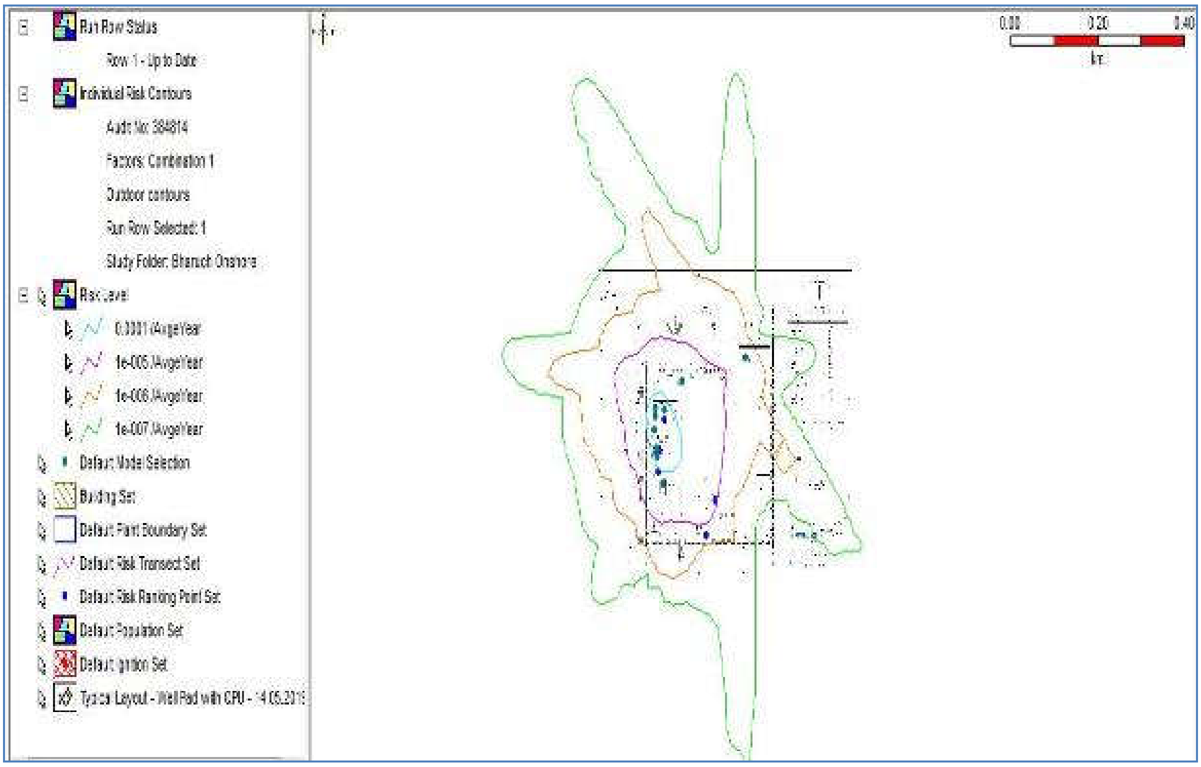


Figure 7.10: LSIR Contour

The above Risk Contour (LSIR) is generated on the basis that each target location considered is permanently inhabited by a single individual. LSIR Contours are indicative of the potential magnitude or intensity of the risk, but the risks will only be realised at a given location if personnel will be present at that location 24/7.

It may be noted that the above risk estimation is based on the basic failure frequency listed for the various components. Consequences were assessed based on the tank inventory. Some of the specific design aspects such as design overpressure and corrosion allowance, provision of PSVs, Material of Construction complying with NACE can bring down the failure frequency by an order of magnitude. Detection and control such as Fire & Gas detection systems which generate alarm drawing the attention of operators and/ or activate safe shutdown with a minimum PFD of 1E-01 should also be considered as risk management hierarchy.

7.1.6.2 Incremental Individual Risk Per Annum

Individual Risk or Individual Risk Per Annum is determined on a case by case basis for each individual working. The individual risk levels have been calculated by multiplying the above LSIR levels by the exposure factor (Occupancy Level).

The results of these calculations based on worker groups are presented in below Table;

Table 7.9: Incremental Individual Risk Per Annum (IRPA)

S. No.	Worker Groups	LSIR (Avg/ year)	Occupancy	IRPA (Avg/ Year)
1	Operators	1.87E-04	0.22	4.11E-05
2	Maintenance	1.73E-05	0.33	5.71E-06

Source: ABC Techno Labs India Pvt. Ltd.

From the above Table, the Individual Risk is following into Acceptable Region.

7.1.6.3 Societal Risk

The FN Curve is provided in the following Figure.

From the above Figure, the societal risk falls into Acceptable Region.

7.1.7 Risk Evaluation

As per Risk Tolerance Criteria for Individual Risk and Societal Risk, the Individual Risk and Societal Risk value for all Worker groups falls within the Acceptable Region.

7.1.8 ALARP Demonstration and Cost Benefit Analysis (CBA)

ALARP Demonstration is not necessary as the Individual Risk and Societal Risk falls in Acceptable Region.

7.1.9 Risk Reduction Measures

Though the risk falls under the Risk Tolerance Criteria for Individual and Societal Risk, the following recommendations are made with respect to continual improvement and to increase the reliability of the conditional modifiers:

- Ensure that the portable fire extinguishers are provided at strategic locations as per OISD-117 and it is inspected at regular intervals.
- Fire and Gas Detectors can be provided for early detection warning.
- As Operator Room are likely to be affected due to Blowout scenario, it is essential to ensure the upkeep of the safety devices (Smoke Detection, Fast Rescue Craft (FRC), escape routes and it must be ensured that Mock evacuation drills are carried out periodically.
- The correct installation of Safety Critical Equipment and their operational reliability are essential for the safety of the facility. In addition, initial and periodic testing of the Safety Critical Equipment before installation and periodically is absolutely essential and the same must be ensured.
- Active fire protection should be provided for all equipment falling within the heat radiation intensity of 12.5 KW/m^2.
- The Closed Room such as Control Room, Operator Room, etc. should be positively pressurized higher than the atmospheric pressure.
- Ignition controls such as maintenance of electrical equipment is recommended as per Hazardous Area Classification Study.
- Detection arrangements for Bund fires for HSD Tank through leak detection within the bund and monitoring with CCTV cameras can be followed.
- Ensure that the bund provided can contain the entire Tank Capacity (110%).
- Periodic On Site Emergency Mock Drills and occasional Off Site Emergency Mock Drills to be conducted, so those staffs are trained and are in a state of preparedness to tackle any emergency.
- It must be ensured that Storage Tanks and Road Tankers are NOT overfilled (not more than 80%)- set points/ SOP to capture the same

- Emergency Response Plan should be prepared based on this QRA Study result identifying the required emergency facilities and the detailed procedure for Shutdown, Evacuation and Rescue.
- Permit to work system to be implemented 100 % for hazardous work in the plant.
- Manual call points for fire location identification to be installed in plant premises.
- Fire Fighting System to be made available.
- Escape routes for personnel must be properly protected and kept free of any debris/obstructions etc.
- Ensuring that the public in vicinity of the facility is made aware of the hazards and also the hazards of unplanned and irregular third-party activities- this may be done through frequent safety awareness programmes, warning signage, explicit display of Do's and Don'ts etc.
- Key non-routine activities must be preceded by a Job Safety Analysis and Job or Task Risk Assessment involving key personnel that would be working on the facility.
- Trips and falls hazard, electrical hazards etc. must be minimized through periodic safety audits and site inspections using third party and Internal audit teams. Actions arising out of the audits must be implemented in a time bound manner and followed up for closure.
- Vedanta Limited (Division: Cairn Oil & Gas) must ensure suitable training to all personnel (Company as well as Contractor personnel) to help prevent incidents/ accidents- such training must be refreshed periodically, and a list of trained personnel must be maintained by Vedanta Limited (Division Cairn Oil & Gas).
- Ensure proper (metallic/ metal braided) hoses, gaskets etc. and Road tanker earthing are properly executed.

As the risk is acceptable, the above recommendations are not mandatory for life safety point of view and are aimed to mitigate the asset damage should the fire occur.

The safeguarding of human life is Vedanta top most priority. To this effect, Vedanta Limited (Division: Cairn Oil & Gas) has issued and implemented a comprehensive HSE POLICY backed up with appropriate safety management systems and procedures.

- Vedanta Limited (Division: Cairn Oil & Gas) operating procedures lay a strong focus on hazard identification and risk assessment covering each and every hazardous operation, procedure and equipment. Risks and mitigating measures for each are clearly carried out and measures implemented and monitored. This ensures risk minimization to the worker group.
- The facility is built based on the highest international standards and global best practice. Individual equipment is of highest quality, certified and of highest safety integrity. This ensures risk minimization to the worker group through operational and maintenance periods. In addition, equipment hazard identification has to be carried out for each of the equipment time to time.

The following are some of the protections provided for Blowout scenario.

- The primary protections against blow outs during drilling are the BOPs or Blow out Preventers. These are used to shut in and control the well in the event of gas or oil being encountered at pressures higher than those exerted by the column of mud in the hole.
- BOPs typically consist of 2-3 ram preventers designed at high pressures. The BOPs are hydraulically operated with a second remote control panel situated someway away from the rig for use in emergencies when the rig is unapproachable. Connected to the side of the ram type preventers (usually below the blind rams) are the kill and choke lines which are used to control the well in the event of any imbalance between the drilling fluid column pressure and the formation pressure. Both lines are high pressure 2-3 inch hydraulic pipes, the kill line being connected to the mud circulation system and the high pressure cement pumps and the choke line leading to a back pressure control Manifold and the mud degasser unit.
- In the event of the high pressure kick with the drill string in the hole, the BOP is closed around the drill pipe and the mud is circulated down the drill string and back to the mud tanks through the choke line and back pressure manifold. The manifold consists of a series of valves and chokes - the choke can be adjusted to give the orifice opening required such as to give a back pressure on the well in order to control it. There would be two chokes in order to allow maintenance on one.

- If a kick or blow out occurs with the drill string out of the hole, the blind rams are closed and heavy mud is pumped into the well through the kill line. Any gas can be bled off through the choke line and fluids are usually squeezed back into the formation.
- The correct installation of the drilling equipment and the operational reliability of the BOPs are essential for the safety of well drilling operation. In addition, initial and periodic testing of the BOPs, choke and kill manifolds, high pressure/ heavy mud system etc. before installation and periodically is absolutely essential. Most important is the presence of highly trained skilled personnel on the rig! In addition, the use of the correct drilling fluid in the circulatory system is extremely vital.
- The drilling fluid basically does the following:
  - To cool and lubricate the drilling bit and the drill string
  - To remove drill solids and allowing the release at their surface.
  - To form a gel to suspend the drill cuttings and any fluid material when the column is static
  - To control sub surface pressures
  - To prevent squeezing and caving if formations
  - To plaster the sides of the borehole
  - To minimize the damage to any potential production zone.
- Pressures associated with the sub surface oil, gas or water can be controlled by increasing the specific gravity of the fluid and thereby by reducing the hydrostatic head of the drilling fluid column. The squeezing of formations in the drilled hole can be checked by increasing the hydrostatic head of the drilling fluid. Special additives for the drilling fluid for controlling viscosity, lubricating properties, gelling properties etc. play an important role in the drilling fluid integrity. Sealing agents such as cellulose, mica can also be added to make up the drilling fluid loss into the porous and fractured formations.
- The historical records show that the drilling of an exploration well has a higher chance of blow out occurring than does drilling a development well. A blow out can be

expected for about 400 exploration wells drilled. As a well takes about 20-25 days to drill this equates to one blow out approximately every 50 years if drilling was continuous.

7.1.10 SAFETY SYSTEM FOR DRILLING RIGS

Operational Safety is the foremost concern while working on drilling rig. Derrick floor is the center stage of all the operations and it is most susceptible to accidents. Safety precaution with utmost care is required to be taken as per the prevailing regulation and practice so that accidents can be avoided. Due to advancement in technology, number of equipment has been developed over a period to cater the need of smooth operation on derrick floor. Various standards are required to be referred to cover the variety of equipment used for safe operation in drilling and become cumbersome at times to refer standards for each equipment as per given hereunder;

- ✓ Twin stop safety device (crown-o-matic and floor-o-matic);
- ✓ Fall prevention device on mast ladder with safety belt;
- ✓ Emergency Escape device for top man;
- ✓ First aid box with Stretcher and Blanket;
- ✓ Fire bell /siren;
- ✓ Emergency vehicle;
- ✓ Fire extinguishers;
- ✓ Flame proof portable hand lamp /safety torch;
- ✓ Railling with toe board;
- ✓ Guards on all moving parts;
- ✓ Breathing apparatus (wherever required);
- ✓ Gas detector for hydrocarbon gas &H_2S gas (if required);
- ✓ Safety lines for power tongs;
- ✓ Rotary brake;
- ✓ Hoisting brake lever with safety chain;
- ✓ Emergency shutoff system for draw works;
- ✓ Safety chain for inclined ramp (to prevent fall of any person);
- ✓ Safety belt for top-man with lane yard;

- ✓ Railing on stair case at mud tank/walkways and derrick floor; etc.

7.1.11 General Safe Practices during Drilling Operation

- ✓ Penetration rate will be monitored. In case of any drilling break, stop rotary table, pull out the Kelly, stop mud pump and check for self flow;
- ✓ Different type of drill pipes should not be mixed up during making up the string;
- ✓ Protectors should be used on drill pipes while lifting and laying down the pipes on catwalk;
- ✓ Drill pipe rubber protector should be installed on drill pipes body while being used inside the casing;
- ✓ Before starting drilling, hole should be centered to avoid touching of kelly with casing / wellhead and ensure that no damage is done to well head and BOP;
- ✓ Continuous monitoring of the gain/loss of mud during;
- ✓ BOP mock drill should be carried during drilling / tripping and under mentioned operations;
- ✓ Safe Working Conditions and Practices to be adopted during exploratory drilling operations; etc

7.1.12 Emergency Preparedness

- ✓ BOP drills and trip drills should be done once a week;
- ✓ Deficiency observed in BOP drill should be recorded and corrective measures should be taken; etc

7.1.13 Fire Fighting Facility for Drilling Rig

For the drilling rigs following fire fighting system/equipments should be provided:

- ✓ Fire water system; and
- ✓ First aid fire fighting system

7.1.14 Control of Hydrocarbon release and Subsequently Fire & Explosion during drilling and testing

To detect the release of hydrocarbon during exploratory drilling and testing, hydrocarbon detectors should be placed, so that control measures may be taken to prevent fire and explosion.

Emergency control measures should also be adopted as per Mines Act 1952, Oil Mines Regulation 1984 and Oil Industry Safety Directorate Standard 2000.

As per Oil Industry Safety Directorate (OISD) Standard, for the drilling rigs and well testing following fire fighting system/equipments will be provided:

- ✓ Fire water system; and
- ✓ First aid fire fighting system.

A temporary closed grid hydrant system with monitors, hydrant points and fire hose boxes will be installed to cover well location, and oil and diesel fuel storage tanks. Portable fire extinguishers of DCP, mechanical foam and CO_2 types of sufficient capacity and in sufficient numbers along with sand buckets will also be placed at strategic locations. Electrical and manual siren systems will be provided at the Security Gate of the experimental production facility. Electrically operated siren of 500 m range along with push buttons at appropriate locations to operate the siren will be installed.

Adequate personal protective equipments including sufficient number of breathing apparatus must also be kept ready in proper working condition.

- ❑ **Fire Water System**
  - ✓ One water tank/pit of minimum capacity of 50 Kl should be located at the approach of the drilling site.
  - ✓ For experimental production testing, one additional tank/pit of 40 Kl should be provided.
  - ✓ One diesel engine driven trailer fire pump of capacity 1800 lpm should be placed at the approach area of drilling site.
  - ✓ One fire water distribution single line with minimum 4 " size pipe/casing should be installed at drilling site with a minimum distance of 15 m from the well.
- ❑ **First Aid Fire Fighting Equipments at Drilling Rig**

Portable fire extinguisher on the drilling rig will be installed in line with IS: 2190.

7.1.15 MINOR OIL SPILL

During exploratory drilling of wells and testing operations, details of classification of possible oil spill scenario(s) and respective activities are as follows:

Table 7.10: Classification of Oil spill during Exploratory & Appraisal Drilling

Classification of spill	Extent of spill	Impact	Scenarios	Preventive Measures
Tier 1 ***Response can be adequately addressed using equipment and materials available at the site.***	Spill contained on site.	Minor equipment damage. Brief disruption to operations.	• Diesel fuel refueling (i.e. drill rig hose leaks, overfilling or connection/disconnection incidents). • Drilling fluid (i.e. leaks from tanks, pumps or other associated equipment within the closed loop circuit system). • Drilling fluid chemicals (i.e. chemicals used during drilling; note that the volumes are limited by the storage containers used i.e. 200 L drums etc.). • Hydraulic oil (i.e. leaks from a split hydraulic hose or failed connector; moderate pressure, low volume lines).	One of the following preventive systems or its equivalent shall be used as a minimum for onshore facilities: • Dykes, berms or retaining walls sufficiently impervious to contain spilled oil
Tier 2 ***Response requires additional oversight expertise, equipment, and materials available***	Localized spill with potential for escaping the site or that has escaped the site but is of limited extent	Moderate to major equipment damage/loss. Partial or short-term shutdown of operations.	• Transportation incidents associated with the delivery of diesel fuel to the drill-site (i.e. third party supplier's truck rollover or collision). • Complete failure of an on-site storage tank (e.g. diesel fuel for generators).	
Tier 3 ***Response requires oversight, expertise, equipment, and materials available***	Major incident or a spill that has extended beyond the site.	Extensive equipment damage/loss. Long-term shutdown of operations.	• Uncontrolled fluid flow (blowout) from a well during exploratory drilling in case oil is part of fluid.	

Source: ABC Techno Labs India Pvt. Ltd.

Spill response strategies for combating incidents include:

- **Prevent or reduce further spillage:** One of the first response actions, if safe to do so, is the isolation of the source and prevention of further discharge.
- **Monitoring and evaluation:** Monitoring and evaluation are used to: Determine the location and movement (if any) of the spill, its appearance, its size and quantity, changes in the appearance and distribution of the spill over time and potential threat to the environment and the resources required to combat the spill (i.e. a more effective and coordinated response).
- **Mechanical containment and recovery:** restriction of spill movement through the use of physical barriers (e.g. bunds, booms, diversion swales). Containment would be followed by the physical removal of the spilled material. This may be accomplished using sorbent pads, vacuum trucks, skimmers or other mechanical means appropriate to the material spilled.
- **Protection of sensitive areas:** Bunds or booms will be used to prevent spills from migrating down a watercourse or stream.
- **Clean-up:** This involves earthmoving equipment used to recover the absorbed spill and affected soil. Such operations may involve the collection of significantly greater volumes of material than was originally released.
- Combinations of the above strategies.

Affected area due to oil spill will be isolated. Spilled oil will be recovered and stored. Contaminated earth will be collected and disposed in consultation with Gujarat Pollution Control Board.

7.1.16 MEDICAL FACILITIES

First aids facilities should be made available at the core drilling site and a 24 hour standby vehicle (ambulance) should also be available at the well site for quick transfer of any injured personnel to the nearest hospital, in case an accident occurs and medical emergency arises. Prior arrangements should be made with the nearby hospitals to look after the injured persons in case of medical emergency during core hole drilling and experimental production testing operations.

7.2 RECOMMENDATIONS

Drilling Operations

A majority of accidents occur during drilling operation on the drill floor and may be associated with moving heavy tubular, which may strike or crush personnel. Being struck by objects, falling and crushing usually make up maximum occupational risk of fatality. Mechanical pipe handling, minimizing the requirement of personnel on the drill floor exposed to high level of risk, may be an effective way of reducing injuries and deaths. Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk. Some of the areas in drilling operations where safety practices are needed to carry out jobs safely and without causing any injury to self, colleagues and system are given below:

Maintenance of Mud Weight

It is very crucial for the safety of drilling well. Drilling Mud Engineer should check the in-going & out-coming mud weight at the drilling well, at regular intervals. If mud weight is found to be less, barytes should be added to the circulating mud, to raise it to the desired level. Failure to detect this decrease in level may lead to well kick and furthermore, a well blow out, which can cause loss of equipments and injury to or death of the operating personnel.

Monitoring of Active Mud Tank Level

Increase in active tank level indicates partial or total loss of fluid to the well bore. This can lead to well kick. If any increase or decrease in tank level is detected, shift personnel should immediately inform the Shift Drilling Engineer and take necessary actions as directed by him.

Monitoring of Hole Fill-up / return mud volume during tripping

During swabbing or pulling out of string from the well bore, the hole is filled with mud for metallic displacement. When this string runs back, the mud returns back to the pit. Both these hole fill up & return mud volumes should be monitored, as they indicate any mud loss or inflow from well bore, which may lead to well kick.

Monitoring of Inflow

Any inflow from the well bore during tripping or connection time may lead to well kick. So, it is needed to keep watch on the flow nipple during tripping or connection time.

7.3 DISASTER MANAGEMENT PLAN

7.3.1 INTRODUCTION

In view of the hazards associated with the Oil Exploration and Production industry, it is essential that a disaster control plan be evolved to effectively deal with the situation utilizing the available resources. There are many agencies involved in the activities associated with a disaster e.g. Government, Fire Service, Medical, Police, Army, Voluntary Organization etc. besides the various departments of the concerned organization itself which requires an organized multi - disciplinary approach to the problem.

7.3.2 OBJECTIVE OF DMP

The following are the main objective of Disaster Management Plan:

- Safeguard personnel to prevent injuries or loss of life by protecting personnel from the hazard and evacuating personnel from an installation when necessary
- Immediate response to emergency scene with effective communication network and organized procedures.
- Obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment;
- Identifying persons and to extend necessary welfare assistance to causalities
- Finally, when situation is controlled, efforts are to be made to return to normal or near normal conditions.
- Minimise the impact of the event on the installation and the environment, by:
  - ✓ Minimizing the hazard as far as possible
  - ✓ Minimizing the potential for escalation
  - ✓ Containing any release.

7.3.3 EMERGENCY IDENTIFIED

Typical emergency situations which the Vedanta Limited (Division: Cairn Oil & Gas) business has identified that could occur within its field of operations are:

- Well Blowout

- Fire / Explosion
- Gas Leakage (H_2S, Natural Gas, etc.)
- Natural disaster such as earthquake, floods, storms, etc.
- Human injuries from accidents, falls, etc.

7.3.4 Legal Requirements for Disaster Planning

Relevant statutory requirements, as given below and as amended from time to time, inter alia, are applicable for emergency response preparedness in E&P industry:

- *Oil Mines Regulation (OMR), 1984;*
- *Central Electricity Authority Regulation, 2010;*
- *Manufacture, Storage and Import of Hazardous Chemicals (MSHIC) Rules, 1989 and amended thereof;*
- *The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996;*
- *Explosives Rules, 2008;*
- *Atomic Energy (Radiation Protection) Rules, 2004; etc*

Additionally, all statutory requirements notified by the Central Government or States, from time to time, shall be complied with, as applicable. Clause-72 of Oil Mines Regulations (OMR), 1984 requires the Mines owner to formulate a contingency plan for fire and clause-64 requires development of an emergency plan for petroleum pipelines specifying actions to be taken in the event of fire, uncontrolled escape of petroleum from pipelines. Also, Clause - 45(3) requires preparation of emergency plan for blow-out of oil and gas wells. The rules on "Chemical Accidents (Emergency Planning, Preparedness and Response) – 1996 compliments the set of rules on accident prevention and preparedness notified under the Environment (Protection) Act, 1986, in 1989 entitled "Manufacture, Storage and Import of Hazardous Chemicals Rules" and envisages a 4-tier crisis management system in the country. Vedanta Limited (Division: Cairn Oil & Gas) will follows safety guidelines and emergency response procedures as per the detailed regulations given in the Oil Mines Regulation 1984 and Oil Industry Safety Directorate (OISD) Standard 2000.

7.3.5 Emergency Classification

Severity of accident and its likely impact area will determine the level of emergency and the disaster management plan required for appropriate handling of an emergency. Emergency levels and the action needed for each level are indicated below:

Table 7.11: Emergency classification and response team

Emergency Levels	Category	Response	Health & Safety	Environment	Security / Community
Tier 1 *Local Reactive*	✓ A minor Incident where site / location team requires no external assistance and can control the incident with local resources ✓ Incident Controller must notify the leader of the ERT or EMT as applicable	✓ Emergency Response Teams (IRT)/(ERT)	✓ Minor medical or injury case requiring no external support ✓ Equipment damage with loss of production ✓ Minor fire with minor injury or plant damage ✓ Rescue of trapped and injured personnel	✓ Minor oil spill < 100T(700b bls) ✓ Onsite environmental Exposure contained with internal efforts e.g. chemical spill ✓ Notification of cyclone within 72 hrs	✓ Minor security breach ✓ Theft from site ✓ Local unrest
Tier 2 *Tactical*	✓ Substantial Incident ✓ EMT leader decides to activate EMT ✓ EMT leader must notify CMT Leader	✓ Emergency Management Team (EMT)	✓ Any incident requiring additional/external resources ✓ Fire or Explosion ✓ Injury or illness requires evacuation ✓ Traffic accident requires external assistance ✓ Well blow out	✓ Oil spill from >100T but <1000T (700–7000bbls) ✓ Environmental exposure requiring outside help ✓ Earthquake ✓ Flood or Cyclone warning Yellow alert –within 12 hours	✓ Community protest or security breach ✓ Major criminal activity
Tier 3 *Strategic*	✓ Crisis situation ✓ CMT leader decides to activate CMT CMT leader must notify the Chief Executive Officer	✓ Crisis Management Team (CMT)	✓ Incident leading to loss of facility ✓ Incident leading to significant financial loss ✓ Incident leading to multiple injuries or fatality ✓ Well blowout ✓ Incident which could lead to international media interest ✓ Major traffic incident with multiple casualties	✓ Oil spill more than 1000T (7000bbls) ✓ Major Earthquake	✓ Terrorist activities/bomb threat ✓ Kidnap or extortion/threat ✓ Major civil unrest/community protest

Source: ABC Techno Labs India Pvt. Ltd.

7.3.6 ON-SITE EMERGENCY RESPONSE PLAN

The Onsite & Offsite Disaster Management Plan (DMP) and Emergency Response Plan (ERP) are planned for facilities, which are also extended to proposed activities. The scope of the DMP On-site Emergency Preparedness Plan is to evaluate the various types of emergencies that can occur at rig installations and processing/production facilities (Drilling and Production activities) and to formulate emergency plans, procedures that can be implemented by Vedanta Limited (Division: Cairn Oil & Gas) in house. In case the contingency exceed in dimension or geographical coverage beyond Vedanta Limited (Division: Cairn Oil & Gas)'s capability, the offsite Emergency plan shall be activated concurrently with the help of District administration. Based on the incident classification and response team matrix mentioned above, Incident Response Team, Emergency Response Team and Emergency Management Team gets involved).

Tier 1 Incident Response Team (IRT):

- The emergency or incident can be effectively and safely managed, and contained within the site, location or facility by local staff.
- Emergency or incident has no impact outside the site, location or facility. IRT may provide support through effective interaction with local stakeholders.
- Loss of life or severe environmental damage or material loss of asset or organisation's reputation is not a consequence of event / emergency.

Tier 1 incidents are managed by Site IRT, each site has own IRT.

Tier 1 Emergency Response Team (ERT):

- The ERT provide assistance and local support to the IRT's in relevant area.
- The ERT have access to local outside site / external emergency services.
- For tier 2 emergency events.

Tier 2 Emergency Management Team (EMT)

- The incident cannot be effectively and safely managed or contained at the site location or facility by operational local staff and additional support is required.
- The incident is having or has potential of impact beyond the site, location or facility and external support may be required.

- Loss of life or severe environment damage or loss of asset or organisation's reputation is possible consequence of event / emergency.
- IRT may provide support through effective interactions with local stakeholders.
- ERT acts as interface between EMT and IRT for Midstream pipeline operations.

Tier 2 EMT is primarily for tactical response to the incident but may on occasions required to act in reactive mode.

Tier 3 Crisis Management Team (CMT):

- The incident has escalated to a level having potential of loss of life, adverse effect on public or company's operations / reputation.
- Incident may have requirement of immediate action / guidance from Top Management.

Tier 3 incidents are incident escalating to the point requiring involvement of CMT

7.3.7 Roles and Respobsibilities of Individual Response Organisation

The Incident Response Team is responsibility for managing all incidents and emergencies which may occur at or in close proximity to their operational area. For emergencies where additional/external support is required the person in charge of the incident response, the Incident Controller at a remote location, site or facility must notify and request support and assistance from the next level in the emergency management organisation. The ERT / EMT should be notified of all incidents within 30 minutes of the IRT activation at a remote location, site or facility.

The key role and responsibilities of the IRT Leader will be

- To manage the response to any and all incident or emergencies at the Site, Plant or Field Location
- To Control the incident by preventing escalation and minimizing risk to personnel
- Direct and coordinate the activities of the Incident Control and Forward Response Teams.
- Ensuring sufficient trained and competent personnel are available to support the Response Teams.
- Ensuring the safety of all personnel working at the Site, Plant or Field location
- Evaluate and initiate immediate actions, to contain and mitigate effects of the incident or emergency. Monitor the situation & determine need for evacuation.

- Establish head count and potential whereabouts of any missing personnel and if necessary prepare search, rescue and recovery plan.
- Follow Incident Response Plan and if required develop a plan of action to deal with the incident or emergency and communicating this plan to the IRT members

❑ ***Emergency Management Team (EMT) – Tactical/Strategic Response***

In the event of an incident or emergency the Emergency Management Team Leader will make a decision whether or not to mobilise the EMT. If the decision is taken to mobilise the EMT then all EMT duty personnel are required to proceed promptly to the Emergency Management Team Room and manage emergency in accordance with their role, responsibility and as directed by the duty EMT Leader. DOA shall be nominated for absence.

The EMT organisation has following roles and responsibilities:

- EMT Leader – In overall in-charge / team leader, responsible for Company's tactical response to all emergency situations in respective SBU. They are also responsible for reporting incidents to the regulating authorities.
- Human Resources Coordinator – Responsible for providing HR services advice and support
- Logistics Co-ordinator – Responsible for providing transport and logistics support as required
- Operation and Technical Coordinator – Responsible for providing operational and technical support and advice
- Finance – Responsible for providing financial support and advice.
- HSE Coordinator – Responsible for providing health, safety, environmental support and response.
- Recorder – Responsible for maintaining a timed log of key events and actions
- Security Coordinator – Responsible for providing security support advice and assisting others as required by EMT Leader

The above list identifies a number of key EMT roles, following additional supporting roles may be called on when as and when required, typical roles being:

- Air Medevac Nodal Officer – Responsible for facilitating air medevac.

- IT/Telecommunication Co-ordinator – Responsible for providing the EMT with technical support associated with the communications hardware and software
- Company Medical Officer – Responsible for providing advice and assistance on health and medical issues.
- Legal – Responsible for providing support on legal / regulatory aspects.
- Public Relation / Corp Com – Responsible for communication with media and external stake holders.
- Contractor's representatives – who may be called in to assist the EMT should the incident involve members of their organisation

❑ ***Crisis Management Team (CMT) Roles***

The Crisis Management Team is comprised of small core of senior executives. The CMT will collectively have responsibility for all major actions taken before; during, and after the crisis situation has occurred.

The role and responsibilities of the CMT will be:

- Select additional specialist resources to join the CMT or to advise the CMT during a crisis, depending on the nature of the crisis
- Develop and implement crisis management strategy
- Develop and communicate the operating mandate of the CMT to those with responsibility for the on-scene activities
- Nominate spokesperson to cover media interviews
- Establish contact and communicate with appropriate government or other agencies
- Prepare to coordinate business continuity and recovery strategy.

7.3.8 Emergency Response Strategies / Evacuation Plan

Emergency response strategies (ERS) are the documented decisions on required emergency response measures for identified emergencies, based on risk evaluation and assessment process. It shall consider all statutory requirements applicable to the installations.

The objective of ERS is to identify the means to be used to secure adequate emergency response. It provides basis for monitoring of the adequacy of the emergency response measures so that they can be modified when essential. ERS should include appropriate standard of performance for response measures associated with each type of identified major accident hazard and installation specific factors.

ERS should include the following elements:

- Organisation
- Procedures
- Equipment
- Information
- Competency building measures (Training & refresher courses and Drills & exercises)
- The role of any other measure essential for achieving successful emergency response

Emergency response measures shall consider the available resources as below:

- Installation resources: They are immediately available on the installation and are under control of installation Manager/In-charge. These include personnel and equipment that can be assigned emergency role.
- Area resources: These resources are available on the installations in the vicinity, within same area and are not under control of Installation In-charge. The resources may be available within the Vedanta Limited (Division: Cairn Oil & Gas) or available by a mutual aid or cooperation agreement.
- External resources: These resources are available by a mutual aid or cooperation agreement at regional, national or international level and include organisations, professional bodies and resource persons.

The general requirements as per Vedanta Technical Standard VED/CORP/SUST/TS 13 on Emergency and Crisis Management are:

- Crisis situations shall be managed centrally by Cairn Oil and Gas business, in accordance with the requirements outlined in the standard.
- SBU operations shall also have procedures in place to ensure crisis situations are escalated to Vedanta Limited (Division: Cairn Oil & Gas) business and Vedanta Group as appropriate.
- Emergency situations shall be managed by SBU operations and reported to Vedanta Limited (Division: Cairn Oil & Gas) business and Vedanta Group as appropriate.

- Incidents shall be managed at the SBU operation level and reported in accordance with SBU operations, Vedanta Limited (Division: Cairn Oil & Gas) business, Vedanta Group and regulatory reporting requirements. Also refer Management Standard MS11 on Incident Reporting, Escalation and Investigation.
- Emergency Preparedness and Response Plans shall be developed, implemented and maintained at the SBU operation, Vedanta Limited (Division: Cairn Oil & Gas) business and Group level to deal with incidents, emergencies and crisis situations.

Additional Vedanta Limited (Division: Cairn Oil & Gas) requirements are:

- The objective of emergency response planning is to have clear written procedures for expected actions during anticipated emergencies. Emergency response plan includes operational and procedural requirements for various emergency scenarios that are relevant for the installation.
- Ensure that appropriate resources and incident/emergency response plans are prepared, practiced and available. The procedures shall include provision for emergency arrangements with contractors.
- Critical resources of emergency response should include:
  - Emergency power systems
  - Fire and gas detection systems
  - Active fire protection
  - Passive fire protection
  - Shutdown system
  - Explosion mitigation and protection systems
  - Evacuation escape and rescue arrangements
- Business continuity and recovery programme (BCRP) to be developed, implemented, tested and maintained. The BCRP shall be risk-based, documented and communicated.
- Every Vedanta Limited (Division: Cairn Oil & Gas) business unit (including projects and offices) shall be covered by trained Incident and Emergency Management Teams who will manage and execute the emergency plans.

- All members of the emergency organisations should be trained and competent to perform their assigned role within the incident response team (IRT)/emergency response team (ERT)/ emergency management team (EMT).
- Arrangements for emergency medical treatment shall consider injuries to persons as a result of minor accidents & major accidental events, illness of persons on installation, transportation & evacuation of sick and injured personnel.
- Controlled medicines shall be stored in a secure place accessible only to those who are trained to administer these.
- The level of medical facilities and trained personnel provided should be in line with the requirements identified in emergency response strategy. Key points to be considered is identification of medical facilities/hospitals
- Emergency response plans shall comply with all relevant legislative and regulatory requirements to ensure emergency capabilities are maintained and achieved.

Procedure for designing emergency response measures should be based on:

- Integration of emergency response with / into design and operations
- Automatic or remotely operated safety systems to mitigate the effects of an incident
- Emergency response organisation structure
- Wherever applicable offsite emergency response / disaster management plans shall be ensured.
- Essential safety system (such as control stations, temporary refuge, muster areas, fire pumps) shall be located where they are least likely to be affected by fires and explosions.
- Emergency shut down (ESD) system shall be designed such, that it is capable of fulfilling its function under the conditions of incident. If installation is in operation, the essential shutdown functions shall be available during maintenance activities, which affect the operation of the ESD system. ESD system shall contain facilities for testing of input/output devices and internal functions.
- Evacuation and escape routes shall be provided from all areas of an installation where personnel may be expected to be present during their normal activities. Alternative

means to allow persons to safely leave the installation in an emergency shall be provided.

- Evacuation and escape routes shall have adequate illumination with emergency lighting and shall be marked to ensure that 'they can be used during emergency conditions'. All escape routes shall be unobstructed (including vertical clearance) and readily accessible.
- Personal protective equipment for use in major accident hazards should be suitable for the circumstances in which it may have to be used and the individuals who may have to use it.
- PPE for use in an emergency should be for all persons on the installation for use in condition of fire, heat, gas release or smoke to enable them to reach muster areas, temporary refuges and evacuation or escape points. Those with specific emergency duties shall also be provided appropriate PPE for use like fire suits and breathing apparatus etc.
- During an emergency, security arrangements shall ensure that unauthorised persons do not enter the incident site by controlling assess and if need arises the area around the site can be evacuated and cordoned to ensure safety of the persons.
- Environmental emergency response should consider:
  - Oil-pollution control equipment that should be located on the installation
  - Environmental conditions that may be present when the equipment is deployed
  - Capacity of the oil recovery system
  - Characteristics of the oil / emulsion to be recovered
  - Means to identify the extent of the spill
  - Facilities to handle any recovered oil.
- International conventions have introduced the requirements to develop national plans for oil-spill response in offshore, and Offshore Assets/SBUs/Operations should ensure that their installations' emergency response plans are aligned with the national requirements.

❑ **Responsibilities of the Employees**

The establishment and maintenance of best possible conditions of work is, no doubt, the responsibility of the Project Management. It is also necessary that each employee follows prescribed safe methods of work. He should take reasonable care for the health and safety of himself, or his fellow employees and of other persons who may be affected by his action at work. With this in mind, employees shall be trained to be health and safety conscious in the following aspects:

Report	***Potential Hazards***
Observe	Safety rules, procedures and codes of practice
Use	Tools and equipments with all care and responsibility
Participate	In safety training course when called upon to do so.
Make	Use Of safety suggestion schemes
Take	An active and personal interest in promoting health and safety

Each unit shall identify and document the resources required to ensure the effective implementation of the emergency and crisis management procedures. Resource requirements shall meet the requirements of the Vedanta Management Standard MS01 on Leadership, Responsibilities and Resources. The following resources shall be considered and made available as necessary:

- Trained and competent personnel;
- Equipment and other materials including Personal Protective Equipment (PPE); Warning devices;
- Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation;
- Emergency services support; and
- Emergency funding, along with an appropriate mechanism for delivering funds.

The capacity of external resources, such as local firefighting capacity, shall be assessed, and additional resources acquired and maintained at the operation where external resources are deemed insufficient.

The resources identified shall be maintained and tested on a regular basis, and their adequacy reviewed periodically.

- **Communication Systems**

Emergency response relies upon effective and reliable communication between all personnel involved in response. Communication systems shall:

- Provide sufficient reliable information/alarm to personnel on the installation to enable them to take the appropriate emergency actions.
- Provide means for those on the installation to communicate with the person in overall charge.
- Provide reliable arrangements to allow the person in overall charge to communicate with all personnel on the installation regarding the nature of any emergency and the actions they are required to take.
- Provide reliable means to allow the person in overall charge to communicate with area and external resources who have a role in emergency response.
- Suitable equipment, information processing and procedures shall be in place to enable effective communications. The means of communication shall be selected based on the need for communication in likely scenarios including operational conditions under which they are to function like, noise, ambient conditions and susceptibility to damage. So far as reasonable, communication arrangements should remain available throughout the emergency
- Alarm signals used and their meanings should be described in the emergency response plan along with the procedures to be followed in the event of an alarm. Persons should be provided with adequate information to allow them to, initiate alarms where necessary, distinguish between alarms and respond to alarms.
- Adequate alarms and warning devices, along with other forms of communication, shall be maintained to reliably alert persons across the whole site in the event of an emergency.
- Independent secondary/back-up communications systems shall be provided in case the emergency incident makes the normal communication system inoperable.
- Ensure that the means are in place to alert to the connected installations, the local community/neighboring businesses in the event of an emergency that has the potential interface with them.

❑ **Training and Emergency Response Drills/Mock**

All persons on the installation or in connected activities (including contractor's personnel) shall be trained periodically for emergency response and evacuation procedures. Training for employees having assigned roles in emergency response shall be completed before they are called upon to perform in real emergencies. Emergency response organisation structure (IRT/ERT/EMT/CMT) shall ensure command by competent persons, which can be maintained, so far as is practicable, throughout an emergency.

- Key persons such as the Installation Incharge and Shift Incharge/control room operator shall be assessed for required competence to perform emergencies duties before assigning of duties. As far as possible, assessment should be under simulated emergency conditions.
- Competency and training needs shall meet the requirements of the Vedanta management Standard MS06 on Competency, Training and Awareness
- An emergency response table top exercise/emergency response drill is a focused activity that places the participants in a simulated situation requiring them to function in the capacity that would be expected of them in a real event. Its purpose is to ensure preparedness by testing policies and plans and by training personnel. One objective of an exercise is to be able to identify problem areas for resolution/corrective action before an actual emergency occurs.
- The drills need to address the readiness of personnel and their familiarity/proficiency with emergency equipment and procedures. All personnel on the installation involved including contractor's employees should participate in the drills.
- The drills and table top exercises shall be carried out as often as appropriate, against documented schedule. To be scheduled regularly, at least once a year for full drills and six monthly for desk-based exercises, although the exact frequency and type of drills may depend on the nature and scale of the operations, and the associated risks.
- Emergency response plan shall be reviewed and revised as appropriate in line with the findings from drills and table top exercises.
- Involve external emergency response agencies and other external stakeholders, where appropriate.

❑ **Performance Measures**

- Key elements of functionality, survivability, reliability and availability shall be included in performance standards. Achievability of performance standards should be validated.
- Effective operations, inspection, testing and maintenance procedures shall be established to ensure that the functional requirements of the equipment and systems provided for emergency escape, evacuation and rescue response are maintained.
- A written scheme shall be prepared, detailing the inspection, testing and maintenance routines and frequencies to be followed. All emergency equipment and systems shall be thoroughly inspected, following established procedures. Adequate records of the results of the inspection, testing and maintenance shall be kept and shall be periodically reviewed to confirm that the written scheme is appropriate and is being adequately implemented.

❑ **Monitoring, Evaluation and Review**

Documented reviews should be carried out after all drills and actual emergency responses to determine the effectiveness of the Emergency Preparedness and Response Plans, with a full debrief to identify what worked well and what aspects require improvement.

Lessons learned following exercises or actual emergency situations/incidents shall be documented, and any gaps in planning and implementation shall be addressed in revised versions of the Emergency Preparedness and Response Plans. Lessons learned shall be shared across Vedanta's operations where appropriate.

All Emergency Preparedness and Response Plans shall be reviewed and updated periodically, at least on an annual basis, to ensure they remain appropriate and relevant. Reviews shall also meet the requirements of the Vedanta Management Standard MS14 on Management Review and Continual Improvement.

❑ **Preventive and Mitigation Measures for Well Blow out**

Blow-out (uncontrolled gushing of oil & gas) is the worst situation, which may arise at oil wells during drilling, work-over operations, perforation, and reservoir studies at active wells, etc. or due to some unforeseen reasons.

A blow out, though rare, in a drilling operation is often accompanied by fire and explosion exposing workers to serious danger to their lives, burns and poisoning. To understand the failure modes resulting to formation of kick and subsequent blow outs, one has to understand the safety systems installed for blow out prevention.

Prevention of blow outs rests primarily on control of any kick in the well bore. A kick means entry of formation fluids into well bore in large enough quantity to require shutting in the well under pressure. Once a kick is detected, steps can be taken to control entry of formation fluids into the well bore by over balancing the expected bottom hole pressure with properly conditioned mud and operation of safety valves i.e. Blow Out Preventer (BOP), whereby the space between the drill pipes and the casings can be closed and well itself shut off completely. Several instruments are provided on a drilling rig for detection of kicks.

- **Instrumentation in Mud System**

Continuous monitoring of condition of mud in the well provides information useful for well control. The following processes are used in the drilling mud system for this purpose:

- A pit level indicator registering increase or decrease in drilling mud volume. It is connected with an audio-visual alarm near the drillers control panel.
- A trip with float-marking device to accurately measure the volume of mud going in to the well. This is useful to keep the well fed with required quantity of mud at all times.
- A gas detector or explosive meter installed at the primary shale shaker together with an audio-visual alarm at the drillers control panel to indicate the well presence of gas-cut mud in the well.
- The kick in the well is prevented by keeping the hydrostatic head of the drilling fluid greater than the formation pressure. The primary control can be lost in the following situations:
- If there is reduction in hydrostatic pressure in the well due to swabbing, which maybe caused if the drilling string is pulled out too fast or by a balled-up or clogged bit, which is indicated by insufficient filling of mud.

- **Preventive Measures for Handling Natural Gas**

The natural gas is a colourless, odourless, flammable gas, mainly methane which may cause flash fire. Electrostatic charge may be generated by flow, agitation etc. No occupational exposure limits have been established for natural gas. The preventive measures to be taken to avoid impact due to leakages are

- Provide local exhaust ventilation system: Ventilation equipment should be explosion-resistant if explosive concentrations of material are present.
- Gloves: Wear appropriate chemical resistant gloves.
- Respirator: Under conditions of frequent use or heavy exposure, respiratory protection may be needed.

- **Leakage of H_2S Gas**

Hydrogen sulphide is a colourless, flammable, extremely hazardous gas with "rotten egg" smell. Low concentrations of H_2S irritate the eyes, nose, throat and respiratory system e.g. burning / tearing of eyes, cough, and shortness of breath. Repeated or prolonged exposures may cause eye inflammation, headache, fatigue, irritability, insomnia, digestive disturbances and weight loss.

The preventive measures to be taken up in case of presence of H_2S in geological formation, appropriate mitigation measure will be taken up:

- Stop the source of leakage (i.e. close the well)
- Remove victim, if any to fresh air, if breathing, maintain victim at rest & administer oxygen, if available, if person is not breathing, start artificial respiration immediately or start mechanical/ automatic resuscitator. Call ambulance and sent victim to hospital or doctor.
- Pull out all inflammable material i.e. HSD, Gas Cylinders, Chemicals etc. from the premises of well / installation.
- Pull out all possible equipment to safe distances.
- Call for fire tender and start spraying water on the sources of leakage to dissolve H2S in water.
- Evacuate personnel in 500 mts area from down wind direction.
- Warn nearby inhabitants, if required.

Vedanta Limited (Division: Cairn Oil & Gas)'s operations in the Block have indicated that there is no naturally occurring H_2S in the reservoir and therefore release of H_2S during drilling operations is not expected.

- **Preventing Fire and Explosion Hazards**

Fire is one of the major hazards, related to oil and natural gas well. Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire on a platform. Personnel should understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended:

- Fire control cannot be achieved until the source of fuel and ignition is isolated. Fire control cannot be achieved until the source of fuel and ignition is isolated. An emergency shut down (ESD) system shall be provided to isolate the installation from the major hydrocarbon inventories within pipelines and reservoirs, which if released on failure, would pose an intolerable risk to personnel, environment and the equipment/assets.
- There should be provision for safe handling and storage of dirty rags, trash and waste oil. Flammable liquids and chemicals spilled on platform should be immediately cleaned.
- Containers of paints and HC samples, gas cylinders should be stored properly. Gas cylinders should be transported in hand-carts
- Cutting and welding operations should be conducted in accordance with safe procedures
- Smoking should be restricted to designated platform areas and "no smoking" areas should be clearly identified by warning signs
- Platform equipment should be maintained in good operating condition and kept free from external accumulation of dust and hydrocarbons. Particular attention should be given to crude oil pump, seals, diesel and gas engines which could be potential source of ignition in the event of a failure
- The Disaster Management Plan will address the issue of a fire event at any location on the well and the procedure to be adopted in the very unlikely event of this occurring. If a fire starts in any well, that section of the well will be isolated by closing the section (block) valves, as quickly as possible and surrounding facilities will be cooled with water.

7.3.9 Off-Site Disaster Management Plan

The Off-Site Emergency Plan is a compilation of various emergency scenarios and also includes the probable impact off-site locations due to emergency and the action plan to combat/mitigate the consequences of a disaster situation. Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving off-site emergency plan to combat any such eventuality. Emergencies can be handled by an organized multi-disciplinary approach. If it becomes necessary to evacuate people, then this can be done in orderly way.

Under the Environmental (Protection) Act 1986, the responsibility of preparation of Off-Site Emergency Plan lies with the State Government. The Collector/Deputy Collector by virtue of their occupation is normally nominated by the concerned State Government to plan Off-Site Emergency Plan. The different agencies involved in evacuation of people are civil administration (both state and central) and police authorities.

Purpose

- To save life and prevent/reduce loss of properties
- To make explicit inter related set of actions to be undertaken in the event of an accident posing hazards to the community
- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest time

The activities of the government, Non-Government organizations and concerned personnel involved in off-site disaster management plan are as follows:

These will include the safety procedures to be followed during emergencies such as posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts should be circulated to educate the people in vicinity

Medical Help consisted of doctors and supporting staff for medical help to the injured persons because of disaster should be formed. Functions and duties of the committee include, providing first Said treatment for injured at the spot or at some convenient place and shift those to nearby hospitals for further treatment if required.

The police will assist in controlling of the accident site, organizing evacuation and shifting of injured people to nearby hospitals.

The fire brigade shall organize to put out fires other than gas fires and provide assistance as required. Approach roads to accident site and means of escape should be properly identified. Chief fire officer should co-ordinate entire fire control measures. Routine training of fire fighting equipment and special rescue equipment should be carried out. Concerned officer should ensure adequate supply of fire water and fire fighting agents at the site of emergency. Maintenance of standby equipment/personnel for fire fighting should be ready at any given time.

❑ **Mutual Aid**

Disaster/emergency/risk, when becomes difficult to control by in house team/management, help from nearby industries, institutions, etc. can be taken. A group of mutual aid can be formed where emergency control systems like ambulance, fire fighting equipments, medical & fire-fighting team, etc. can be shared in the event of need.

Post Emergency Relief to the Victims.

❑ **General Health and Safety**

The project will adhere to health & safety norms of The Factories Act, 1948, as applicable along with Best Industry Practices.

General health and safety issues during various project activities are similar to those of most large infrastructure and industrial facilities and their prevention and control. These issues include among others, exposure to dust and hazardous materials, hazardous materials components, and physical hazards associated with the use of heavy equipment, etc.

Specific health and safety issues primarily include the following:

- Physical hazards
- Chemical hazards
- Confined spaces

Physical Hazards - The main sources of physical hazards are associated with machinery and vehicles. General electrical equipment safety, working in confined spaces, hot work, high temperature areas are expected to be present.

Chemical Hazards - workers may be exposed to chemical hazards especially if their work entails direct contact with fuels or chemicals, flare & DG set emission or depending on the nature of activities.

Noise - Noise sources include drilling, DG operations, including vehicular traffic. In order to evaluate the impacts of proposed project on the health of workers, baseline health studies will be carried out on every worker before joining their duties.

The hierarchy of control specific for health & safety (in order of priority):

- Eliminate the use of a harmful product or substance and use a safer one;
- Substituting wherever reasonably practicable, a non-hazardous material which presents no risk to health, where a hazardous material is used intentionally, i.e. use a safer form of the product;
- Modifying a process to eliminate the use of risk, the production of a hazardous by-product or waste product, including reducing the quantities of the hazardous material which are used & stored, i.e. change the process to emit less of the substance;
- Enclose the process so that the product does not escape;
- Extract emissions of the substance near the source;
- Provide personal protective equipment (PPE) such as gloves, coveralls and a respirator. PPE must fit the wearer.

❑ **Personal Protective Equipment**

Often it is not possible, or practicable, to eliminate exposure to materials hazardous to health completely. In such cases, operations should consider how to prevent employees being exposed and the prevention of exposure should be achieved by measures other than the use of PPE or Respiratory Protective Equipment (RPE), which is the last line of defence.

Situations where PPE/RPE will normally be necessary include:

- where adequate control of exposure cannot be achieved solely by good practice and the application of operational or engineering measures;
- where new or revised assessment shows that PPE/RPE is necessary until adequate control is achieved by other means;

- where there is temporary failure to achieve adequate control of the process, e.g. because of plant failure, and the only practicable solution to maintain adequate control in the time available may be the provision and use of suitable PPE/RPE; and
- where maintenance operations have to be carried out.

Key personal protective equipments will include:

- Hand gloves
- Helmet
- Safety shoes
- Safety harness
- Eye shield
- Ear muffs

❑ **First Aid**

Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation will be provided at project.

All persons on an installation should have at least basic training in emergency response, basic first aid, use of life saving appliances and firefighting. Individual competencies shall be periodically tested to identify further requirement of training and knowledge to perform emergency duties.

It will be ensured that any auxiliary medical teams e.g. nurse and first aid personnel are fully trained and conversant with their roles and responsibilities.

Contact details & capacities of nearby medical facilities and medical experts will be made available at strategic locations.

7.3.10 Disaster Management Plan for Natural Hazard

Key natural hazards that occur in Gujarat are earthquake, flood, hailstorms storm, etc.

- Earthquake - As per the BMPTC Atlas, various parts of the State of Gujarat fall under earthquake zones III. General awareness and wide dissemination of do's and don'ts through electronic and print media issued by state disaster management agency should be followed.
- Flood - Though most parts of Gujarat receive scanty rainfall, the State has a history of floods and inundations, mostly along the basins of rivers like Luni. Besides the floods in

natural drainage systems, there are other reasons for inundation. Changes in rainfall patterns have also increased the risk of flash floods in many areas that were not flood prone historically. IMD and other government department warnings should be monitored and in case of any such warning, relevant steps as guided by on site disaster management plan should be followed. Instruction given by key departments like IMD, district disaster management center, etc. to be followed.

- Human Epidemics - Although, Gujarat has a history of disease outbreaks such as Cholera, Gastroenteritis, Acute Diarrhoea/ Dysentery, Infective Hepatitis, Encephalitis, Poliomyelitis, Typhoid and recently H1NI; the State is particularly prone to Malaria. Conduct regular hygeine awareness and conduct targeted vaccination drives as required. Workers to be trained for hygienic work environment, sanitation & living conditions.

It has been observed that natural hazards can be minimized by the presence of a well functioning communication/warning system. A well prepared administration needs to have its communication/early warning system in place to enable precautionary & mitigation measures on receiving warning for impending disasters and in the process minimise loss of life & property.

Data from different reliable sources should collected and monitored in real or near real time and analysed to generate a warning alert in the event of likelihood of a disaster.

- The Indian Meteorological Department (IMD) will be the nodal agency for the monitoring of seismic activity, flood, etc.
- Tie up/contacts/communication with State Disaster Response Force (SDRF), district disaster management center should be maintain SDRF has been constituted in the State with stations at locations i.e. Jambusar, Vadodara.
- Local Search and Rescue Team at the local level comprising of retired Army and Police personnel, Civil Defence and Home Guard, volunteers can be identified and trained to perform initial Search and Rescue operations.
- Apart from the above, Community volunteers/representatives would be identified and trained on search and rescue operations through community Based Disaster Management programme.

- Disaster Management and Relief Department website/ communication along with other line departments like fire, police, health, etc. will be checked.